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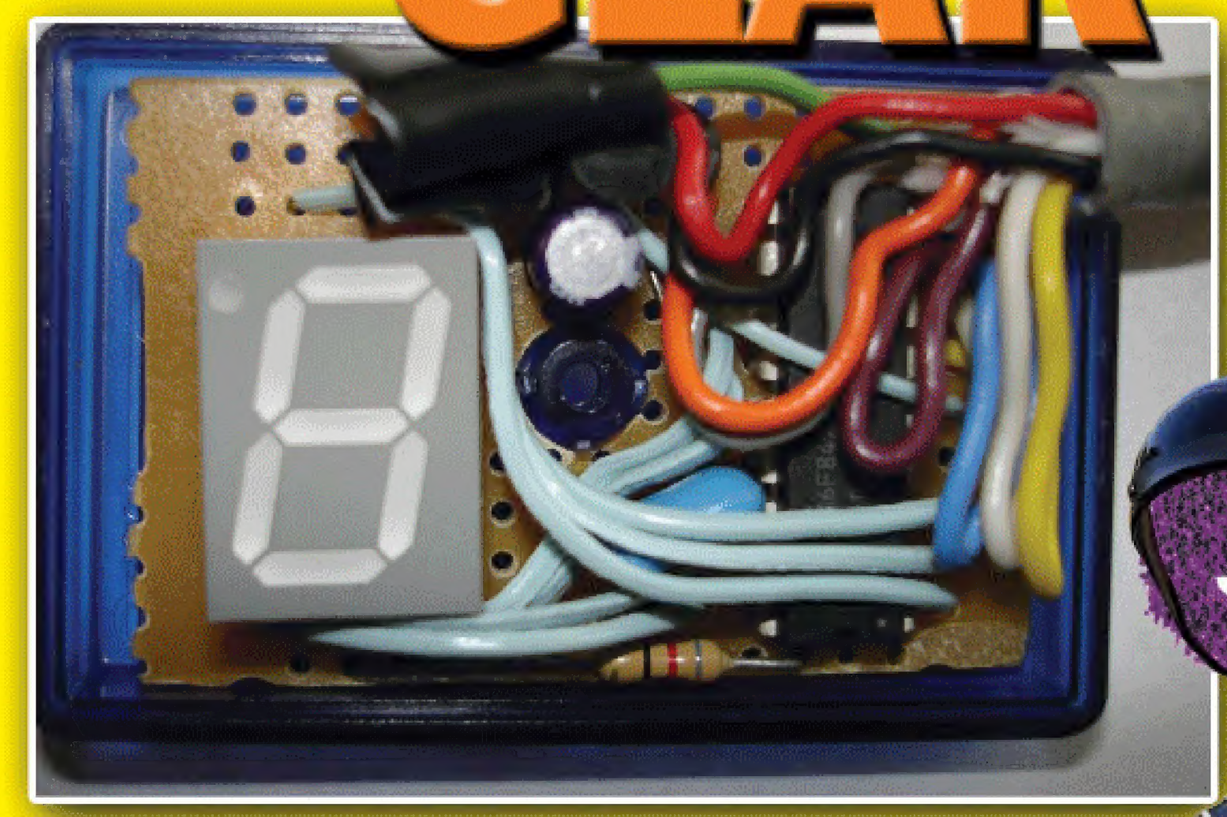

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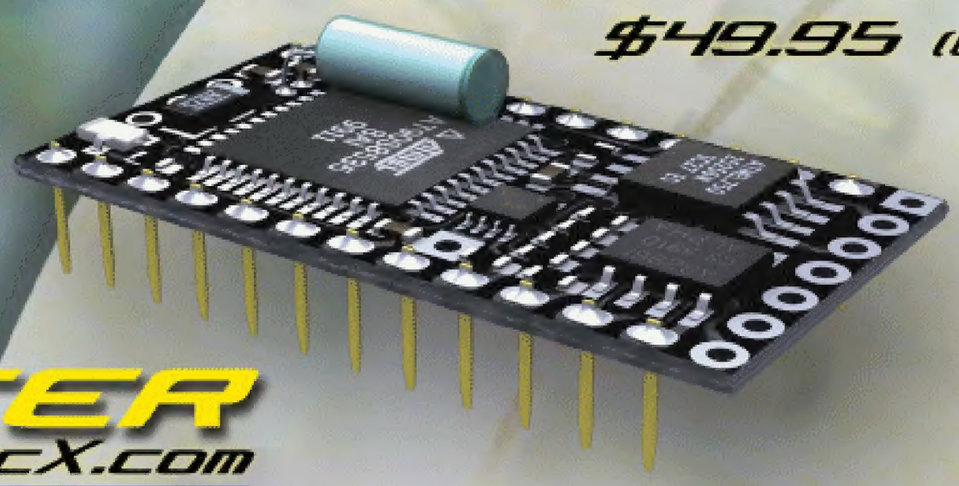

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Nuts & Volts

JULY 2005

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COLUMNS

DEPARTMENTS

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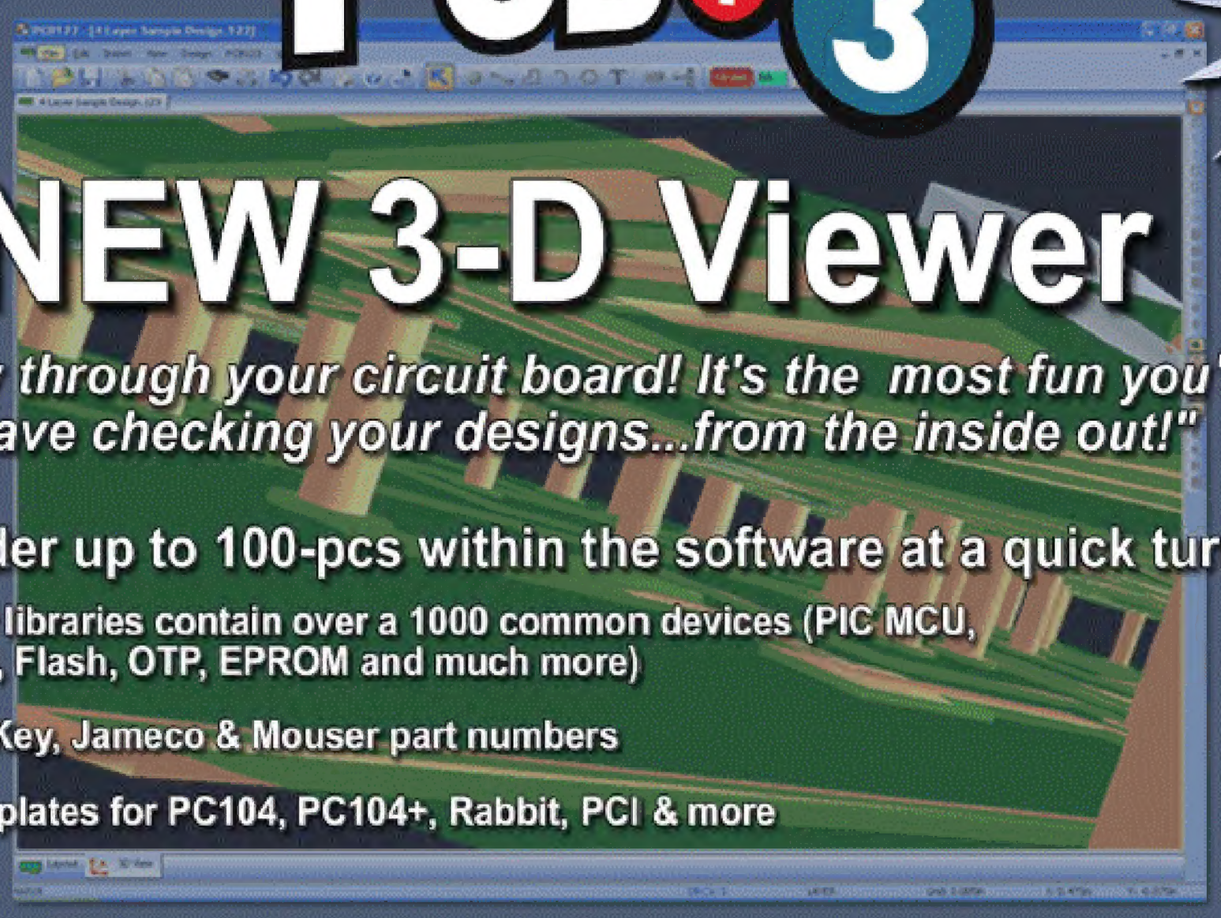

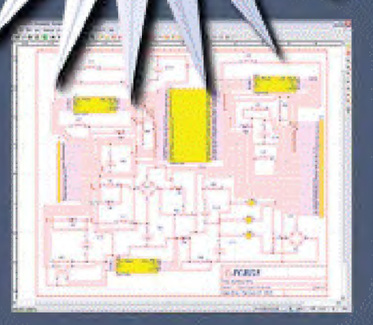

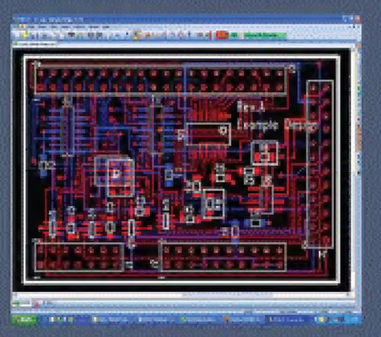

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Reader Feedback

Dear Nuts & Volts:

Thanks for the project-related articles! I especially enjoyed the article on building the coil-winding machine. I've been tempted to not renew my subscription, but due to such well-documented, hands-on projects like this, I'll probably renew. Thanks,

Luke Andrew

Dear Nuts & Volts:

I'm a *Poptronics* convert and have been very impressed with your magazine from the very first issue. I really look forward to your magazine coming in the mail every month. *N&V* is sophisticated for the seasoned veteran, but entry level enough not to scare off the newbie. This is a difficult balance to seek for any skill-based magazine.

Gary Town

Dear Nuts & Volts:

Please ("Spoke Signals," June), the American flag is, in reality, called the American flag, not the "USA" flag (just like the Canadian flag is called the Canadian flag) and in every instance in the article and on the magazine cover, the flag image is displayed in the reverse, both as a photographic backdrop and electronically by the rotating project. Since the LEDs are visible only from one side, the image is being clocked backwards.

Tom Becker

Dear Nuts & Volts:

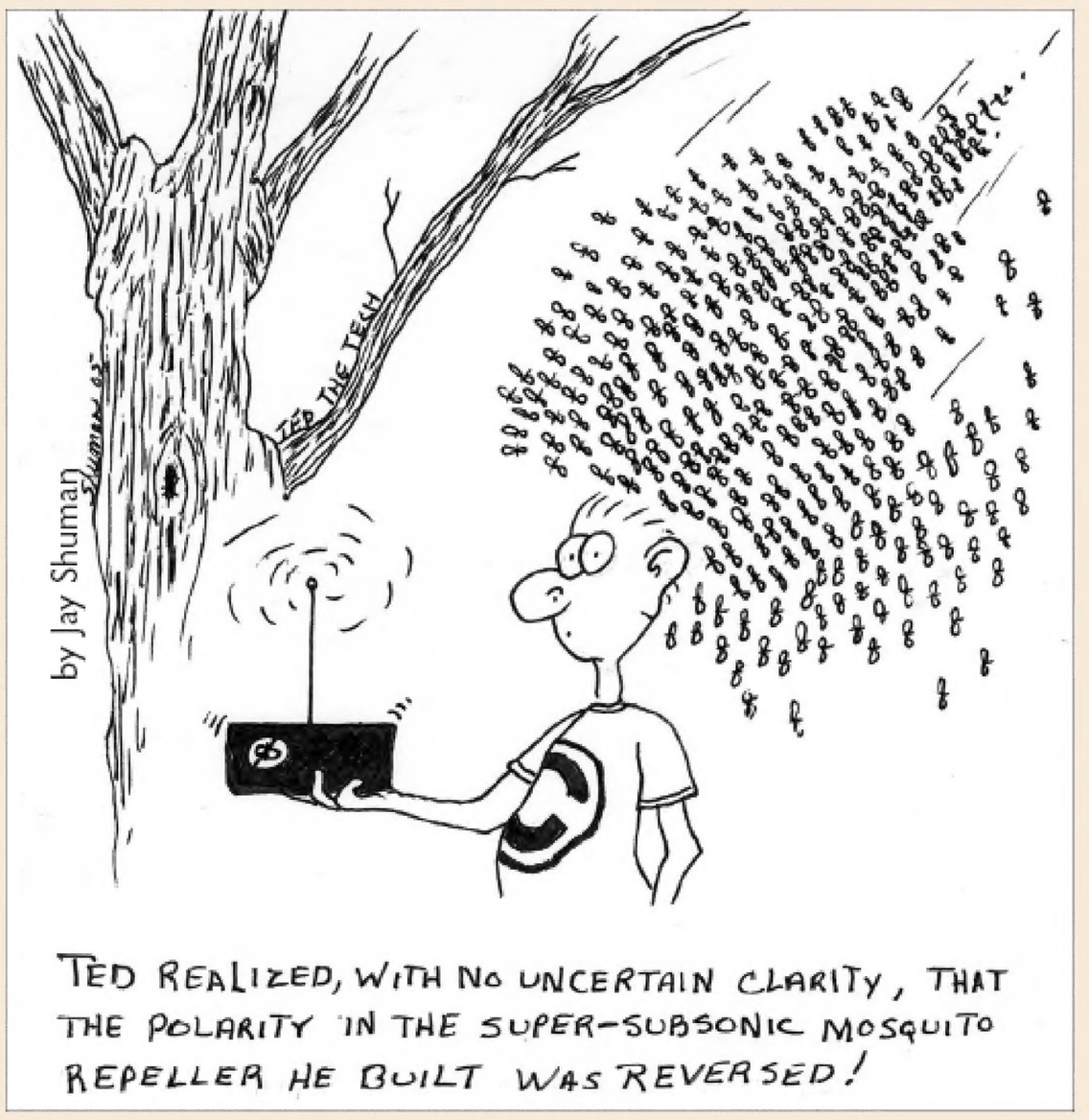
Your cover story of the June issue shows the blinking light project mounted on a road racing bike.

While the project looks fun and mounting it on a cruiser is fine, putting unbalanced weight on the front wheel of a skinny tire bike is a very bad idea. It is good that most of the mass is near the center of rotation. But the complete board will significantly affect the control of a bike at speeds over 20 mph, especially on downhill curves.

The wheel and fork will oscillate and loss of control will soon follow. At minimum, a counterweight should be added to the opposite side of the wheel, so that when spun freely, the valve stem should just settle to the bottom. So, save it for the parade and — since this will encourage night riding — wear light colored clothing and reflective material.

Steve McChrystal

Continued on Page 77



In the June issue, on page 46 of the Coil-Winder article, the sources listed numerically from 4 through 9 were abducted by aliens and somewhat scrambled. Here is a restored list of those sources:

Source 4: **www.nutsvolts.com**
Source 5: **www.logix4u.net/inpout32.htm**
Source 6: **www.allelectronics.com**
Source 7: **www.jameco.com**
Source 8: **Your local hardware store**
Source 9: **Your local hobby shop**

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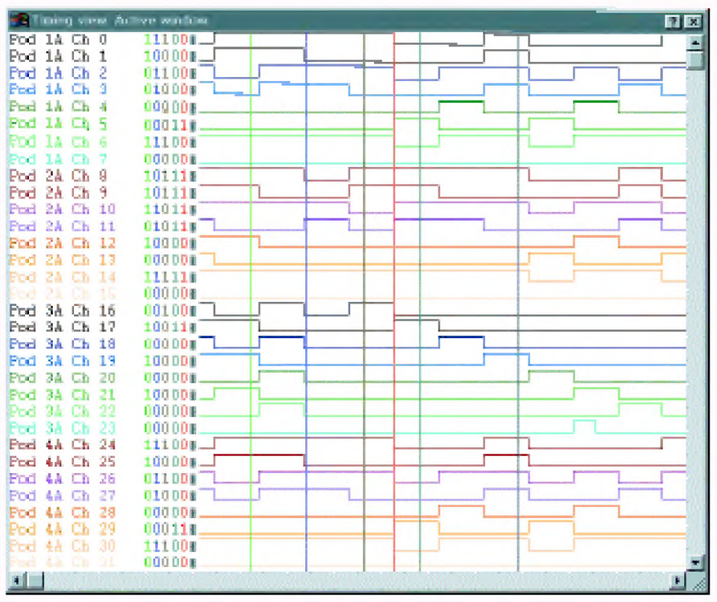

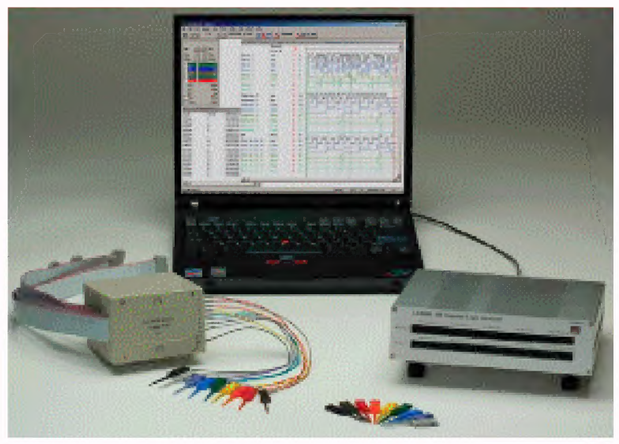

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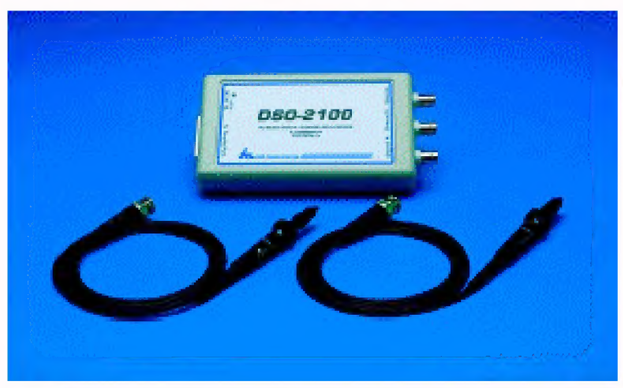

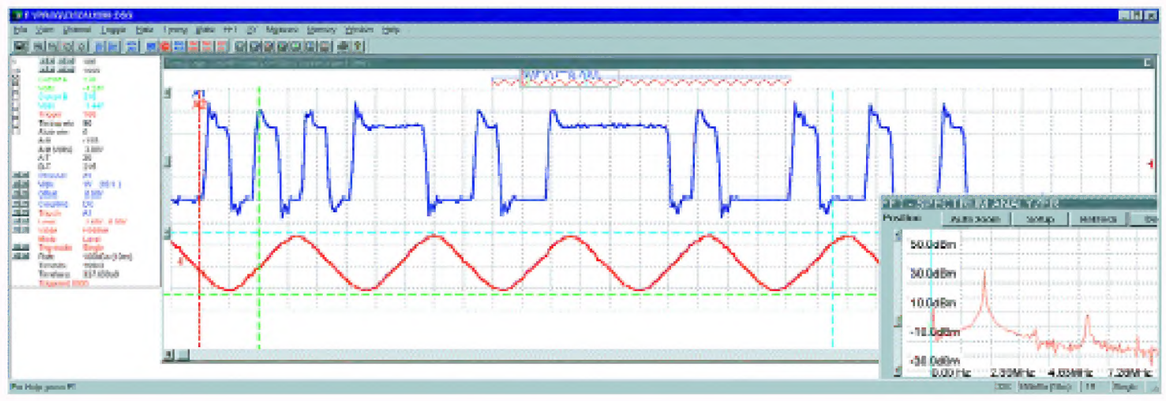

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by Edward Driscoll, Jr.

Micro Memories

Up From the Quonset Hut — Silicon Valley's Computer History Museum Finds a New Home

The article that inspired this series of Micro Memories columns first ran in the July 2001 issue of *Nuts & Volts*, and featured Silicon Valley's Computer History Museum, then located in rather Spartan quarters — a Quonset hut located on the Moffett Field airbase in Mountain View, CA.

Moffett Field is now owned by NASA, but for many years it was a Navy airbase, and to this day, checking in means stopping by a gate manned with rough men who look like they're just back from shore patrol, and require IDs before they'll let just any civilian enter a military base. But it was worth it, to visit a Quonset absolutely filled to the gills with a 120 years or so of computers, robots, calculators, and their predecessors.

It didn't hurt that the Quonset is located directly in front of one of three gianormous hangars built on the base in the 1920s to house some of the blimps the Navy experimented with over the next three decades.

The Computer History Museum (then called The Computer Museum History Center) moved into that Quonset hut after being housed for many years in Boston's Museum Wharf area.

By late 2001 though, there were already plans to move into more spacious digs. Back then, the goal was still to be located on Moffett Field, as part of a planned museum complex honoring California's role in America's aerospace history.

At the time, the plan was to build a temporary prefab, but much larger space than the Quonset hut, while a brand spankin' new ultra-modern museum was being designed by one of several prestigious architects to be chosen by a vote of the museum's board.

But the "dot.bomb" recession at the start of the "naughts" killed that plan, for both good and bad reasons: bad, because funding became that much more difficult. And good, because it created an opening in an existing space very close to Moffett that turned out to be perfect for the museum.

"When the economy tanked," John Toole, the museum's executive director and CEO recently told me, "it really gave us a terrific opportunity to look around to see where we could own our own propertied land, which is sort of a dream that we've had for many, many years." Toole calls it the museum's "chance of a lifetime," which, needless to say, they jumped at.

Welcome to the Museum's Spacious New Digs

And so, in the fall of 2002, the Computer History Museum moved into a 120,000 square foot ultra-modern building originally built in 1994, that's within easy driving distance of Moffett. "The joke that we tell people," Toole quips, "is that we think that this building was built as a museum in 1994 when it was first built, but they just didn't know it at the time."

"It was initially built for Silicon Graphics," he adds. "This was their sales and marketing headquarters, and all their international people would come in here for demos. It was largely a cubical farm when we first approached them, and people were working in the back end of it. But it's a really progressive building for the Valley: it's open and airy, and it's really been great, I think, from our point of view, as well as what our vision is down the road — we want to build this thing out to make it something special as a museum."

Renovating that space has been an ongoing process. Currently, there is a handsome lobby — a large ground

The Computer History Museum exterior.

The hangar and Museum — April 3, 2001.

floor reception area with several exhibits. "Shakey," the pioneering mobile robot built by the Valley's SRI industries who was featured in the September 2004 Micro Memories, is housed in a Plexiglas case there, along with the first Ethernet cable, the first disk drive (which looks to be over three feet in diameter — unlike the device that fits into the 5-1/4" drive bay in your PC, and early Apple Is and Macintoshes, each also similarly protected by Plexiglas. The increased space has also allowed for a larger staff, which has grown from three at the beginning of the Moffett days to 26, currently.

Off to one side is the new version of what the museum calls "The Visible Storage Facility." At 10,000 square feet, it's much larger than its Quonset hut predecessor. It contains the same pieces of "Big Iron" featured in the July 2001 *Nuts & Volts* article, including a hulking Johniac and Air Force Sage mainframes from the 1950s; early IBM mainframes; the sleek but useless Neiman-Marcus "kitchen computer" from the 1960s; and a NASA Apollo guidance computer. More recent computers include a row of stylish Cray mainframes; several cases' worth of 1970s and '80s PCs and their accompanying software; Google's first server farm; and numerous early pocket calculators, robots and even stand-up coin-op videogames from the 1970s.

"It's quite different from the Visible Storage facility that was over in Moffett," Toole is quick to mention. "Now, we've got about 10,000 square feet. We do docent-led tours there every Wednesday, Friday, and Saturday afternoons, which are open to the public. The Visible Storage area only houses ten percent of our collection, but it's an up-close and personal view of the artifacts, but now there are labels there — unlike what we had at Moffett back in the old days!"

The entrance to the Visible Storage Facility.


Johniac mainframes from the 1950s.

Beyond Visible Storage

But the Visible Storage Facility is merely the tip of the museum's iceberg. In the back of the reception hall is another storage facility, normally closed to the public, that resembles the vast warehouse at the end of Raiders of the Lost Ark, except that rather than the Ark of the Covenant (at least, I don't think this museum has that — if they do, they're clearly sworn to secrecy), this warehouse is crammed full of technology — everything from fin-de-siecle stock tickers to at least eight Altair 8080s, to a good half dozen TRS-80 Model IIIs, and all points in between.

Another room, closer to the lobby, has a sign on its door that announces that it is the "PDP-1

Visiting the Museum

The Computer History Museum is located at:

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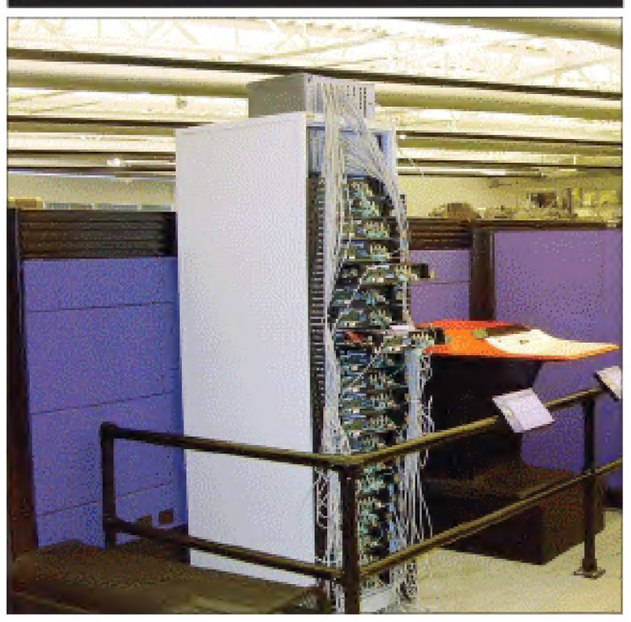
Visit **www.computerhistory.org/about/tour** for complete tour information, including hours and directions.

Row of stylish Cray mainframes.

Early IBM mainframes.

Neiman-Marcus kitchen computer and the Google server.



The Altair 8080s in the storage facility warehouse.

PDP-1 Restoration Lab.

RESTORATION LAB," where engineers who once worked on the DEC beast and its accompanying teletypewriter interface are slowly trying to bring it back to its original form (on their website at **www.pdp-1.org** they announced that they had gotten it to the point where it can run a few simple programs). A whiteboard behind it flowcharts the progress of the restoration, and old manuals are strewn about with information to assist.

Upstairs is the museum's auditorium. Toole says that it has hosted speakers ranging from two Steves, Jobs and Case, to the members of the Pixar animation team. (In mid-May, the men who made The Incredibles were scheduled to stop by, to what was expected to be a capacity crowd.) It can also hold surprisingly large Christmas parties, and other non-techno-oriented events.

All in all, it's quite an amazing space — and should be required visiting for anyone in the neighborhood who wants to learn more about the history of the technology that powers the world, and especially for those who've interacted with some of these amazing machines firsthand.

While I'll miss the atmosphere of the old Quonset hut, and the "zeppelin dome" behind it, the museum's new space is much more easily accessible, and has lots more room to grow. And since you're reading not just *Nuts & Volts*, but this particular column, it's definitely a worthwhile stop if you're in the neighborhood. **NV**

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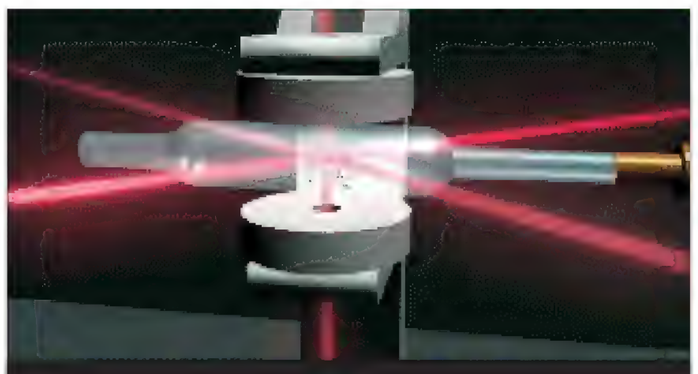
— Jeff Eckert

Advanced Technologies

Another Step Toward a Quantum Computer

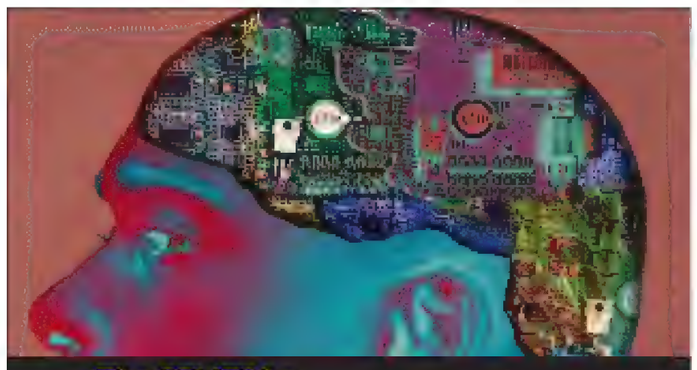


Initial step in the formation of an "egg carton" of atoms. Graphic produced by the Ohio Supercomputer Center, courtesy of Ohio State University.

Before you can build a computer that exploits the quantum mechanical properties of atoms, you have to create something that can hold them. Scientists at Ohio State University (**www.osu.edu**) have taken a step in that direction by making tiny holes that contain nothing at all. These holes, which resemble dark spots in an egg-carton-shaped laser light surface, could someday do the job.

To create such a surface, lasers and magnetic fields capture vaporized rubidium atoms and form them into a pea-sized cloud (see graphic). The device holding the cloud then slides down a track to move the atoms into position above a glass chip. Then, the magnetic fields are shut off, releasing the atoms, which fall onto a surface of laser light. According to OSU, other research teams have created similar arrays, called "optical lattices," but those designs present problems that limit their practical usefulness. Other lattices lock atoms into a multilayered cube floating in free space. But manipulating atoms in the center of the cube would be difficult. The Ohio State lattice is said to have a more practical design, with a single layer of atoms grounded just above a glass chip. In this scheme, each atom could be manipulated directly with a single laser beam.

Security System Mimics Human Brain



The SENTRI system mimics the way the human brain processes sounds. Photo courtesy of the Office of Naval Research.

It's not all that difficult to install a security system that employs various and sundry sensors and annunciators to detect things that don't seem right. The problem is figuring out how to react to whatever it detects. For example, do you interpret a loud "bang" as a gunshot or just a backfire from the pizza delivery guy's disintegrating Hundai? Is the night watchman smart, awake, and sober enough to tell the difference?

This may not be a problem much longer, with the advent of the Smart Sensor Enabled Neural Threat Recognition and Identification (SENTRI) system, developed through research sponsored by the Office of Naval Research (**www.onr.navy.mil**). The system, marketed by Safety Dynamics, L.L.C., uses software that mimics the way the human brain processes sounds to recognize, identify, and locate the source of a range of suspicious noises.

It is based on the work of Dr. Ted Berger, of the University of Southern California Center for Neural Engineering, who created mathematical models to mimic brain activity and applied them to the extraction of signals from background noise, much as the human brain can focus on spoken words within a noisy environment.

The basic concept has been modified for application to other types of sounds. Conceptually, sound identification could be coupled with chemical or optical sensors so that, if exhaust fumes are detected along with a weapon-like "pop," the system would identify the event as a backfire rather than a weapon discharge. If the sound of a door rattling on its hinges is accompanied by the aroma of doughnuts, SENTRI might conclude that the police are trying to break in. And if the reverberation of a voice bellowing "ho, ho, ho" coincides with the aroma of reindeer drifting down your chimney ... well, you get the picture. For details, visit **www.safetydynamics.net**

Microbial Fuel Cells Beat Fermentation

Whenever a friend begins a dissertation on the wondrous hydrogen-based society that will be arriving in, oh, a couple months, I ask a question: Where are you going to get all that hydrogen? This generally derails the conversation, as there presently is no practical answer. However, a germ of a rejoinder may be contained in recent news out of Penn State University (**www.psu.edu**) about the

development of a microbial fuel cell (MFC) that can coax bacteria into producing four times as much hydrogen than generally can be created by fermentation alone. And the process is not limited to carbohydrate-based biomass (plant materials and animal waste). It can even be used to process and clean wastewater.

The key is breaking the "fermentation barrier" by giving the bacteria a 0.25-V jolt, persuading them to convert acetic acid into carbon dioxide and hydrogen. When the bacteria eat biomass, they transfer electrons to an anode. They also release protons (hydrogen atoms stripped of their electrons), which go into solution.

The electrons on the anode migrate via a wire to the cathode, where they are electrochemically assisted to combine with the protons and produce hydrogen gas. According to Bruce Logan, inventor of the MFC, "This new process demonstrates, for the first time, that there is real potential to capture hydrogen for fuel from renewable sources for clean transportation."

Computers and Networking

Mouse Adapter for Disabled

The Assistive Mouse Adapter. Photo courtesy of International Business Machines Corp.

Earlier this year, IBM (**www.ibm.com**) announced the invention of a mouse adapter that enables people who suffer from hand tremors to eliminate excessive cursor movement, thereby allowing more normal use of a personal computer. The design has been licensed to Britain's Montrose Secam Ltd., which is now selling the unit online (**http://montrosesecam.com**) and through representatives.

According to the International Essential Tremor Foundation, some 10 million people in the United States alone are affected by "essential tremor," the most common form of hand tremors. Their involuntary hand movements make it difficult to operate a PC using a standard mouse. The mouse adapter filters out the shaking movements much as the image stabilizing systems used in some camera lenses stabilize the image. The device is designed to work with any PC and operating system, and no additional software is required. The adapter can be switched on or off and adjusted for the tremor severity. It can also be set to filter out unintended multiple clicking on the mouse caused by a shaking finger. Prices run at $99.00 plus shipping.

USB Speaker System

TRITTON Technologies has introduced an external, portable USB-powered 2.1 speaker system called "Sound Bite." This self-contained audio device employs two aluminum microdrivers and a subwoofer, and it features a built-in sound chip that acts as a second sound device or allows older notebooks and systems without a sound card to produce high-quality sound.

The system needs no batteries or power adapters, and it features two 28-mm satellite speakers and one 52-mm subwoofer. It handles 5 W of input power with a maximum output power of 1.2 W + 1.2 W and is plug-and-play and compatible with PCs running Windows 98SE/ME/2000/XP and Macs running OS 9 or later with USB audio support. Listing at $49.95, Sound Bite is available from major online retailers.

One-Inch Drive Stores 5 GB

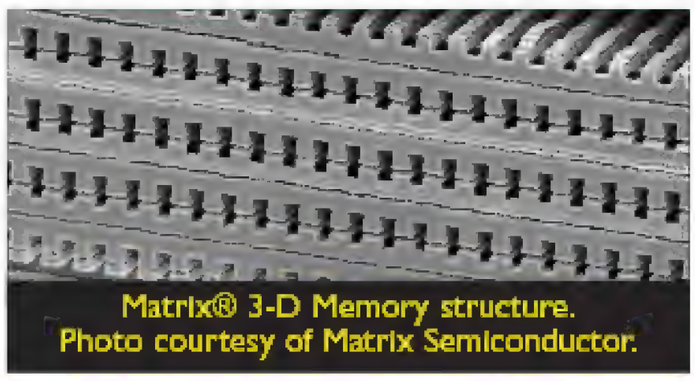
Seagate's USB 2.0 Pocket Hard Drive. Photo courtesy of Seagate Technologies.

If you're looking for an easily transportable storage device, check out Seagate's USB 2.0 Pocket Hard Drive,

a 2.5/5-GB unit that won the 2005 Consumer Electronics Show Innovation Award. It has a distinctive round case that's just over two inches in diameter, designed to fit in a pocket easily. It comes with a retractable USB cable and rubberized feet. It also includes software for data security and content management. You can pick one up on the Internet for about $150.00 (or for 20,900 yen in Japan). Details are available at **www.seagate.com**

Circuits and Devices

"World's Smallest" Memory



Matrix® 3-D Memory structure.
Photo courtesy of Matrix Semiconductor.

Matrix Semiconductor (**www.matrixsemi.com**) recently announced what it bills as the world's smallest 1-Gb silicon memory. Measuring only 31 sq. mm, it employs the company's "hybrid scaling" and "segmented wordline" technologies.

The former combines different process geometries within layers of a 3-D circuit to produce higher densities. The latter, which is patented by Matrix, minimizes the non-memory logic circuitry by building the memory array on top of the logic circuitry, thus reducing die area by nearly 25 percent. By the end of 2005, Matrix expects to have applied these technologies across all of the memory capacities it currently offers (128-, 256-, and 512-Mb), as well as a new 1-Gb 3-D memory. Samples of these new products are available now and will be shipping in volume in the third quarter of 2005.

Audio-Synchronized LED Driver

If your project requires a visual output synchronized with music, you may want to consider the LM4970 Boomer® audio-synchronized light emitting diode (LED) driver, recently released by National Semiconductor (**www.national.com**).

Previous designs required preprogrammed I2C compatible code to control lighting patterns, but the LM4970 gives designers the option of using I2C-compatible pattern control or choosing automatic audio-synchronized pattern generation. If the automatic mode is used, no software or memory storage is needed for pattern control, freeing up memory storage space for other features. The I2C-compatible control bus is also used to turn each driver on or off, control the brightness of the LED, and change the high and mid-range frequency bands.

The internal control features reduce the number of external components, optimizing board space in small form factor applications such as cell phones, MP3 players, PDAs, and other portable devices. Available now in a 14-pin LLP® package, the LM4970 is priced at $0.90 in 1,000-unit quantities. Lead-free package options are also available.

Industry and the Profession

Adobe Acquires Macromedia

Adobe Systems, Inc. (**www.adobe.com**), has announced an agreement to acquire Macromedia (**www.macromedia.com**) in an all-stock transaction valued at approximately $3.4 billion. Under the terms of the agreement, Macromedia stockholders will receive 0.69 shares of Adobe common stock for every share of Macromedia common stock in a tax-free exchange.

Based on Adobe's and Macromedia's closing prices at the time of the announcement, this represents a price of $41.86 per share of Macromedia common stock. It was stated, "The combination of Adobe and Macromedia strengthens our mission of helping people and organizations communicate better. Through the combination of our powerful development, authoring, and collaboration tools — and the complementary functionality of PDF and Flash — we have the opportunity to drive an industry-defining technology platform that delivers compelling, rich content and applications across a wide range of devices and operating systems."

Free Tutorial Previews

The IEEE Communications Society's Enhanced Conference Tutorial Program is now offering a collection of tutorials that were originally presented at its sponsored conferences (INFOCOM, GLOBECOM, ICC, IM, NOMS, WCNC, and ENTNET). Each tutorial reviews current communications topics in network management and computer and wireless communications.

Available programs, which are 2.5 to 5 hours in length, contain the original visuals and a voice-over by the presenter. They are available for purchase at $200.00 for Communications Society Members and $250.00 for nonmembers. A number of free, five-minute previews are provided at **www.comsoc.org/livepubs/tutorials/index.htm**

Slow Mobile Phone Growth

In 2004, worldwide mobile phone shipments saw their strongest annual increase ever, jumping 34% with 692 million units shipped, according to a report from the research group IDC (**www.idc.com**).

The expansion was driven by the demand for color displays and camera phones throughout the world. According to a new mobile phone forecast from IDC, worldwide market growth is expected to continue in 2005, but at a slower pace.

Globally, analysts expect mobile phone shipment totals to slow in most regions as a direct result of the large number of new phones purchased by wireless subscribers in 2003 and 2004. But, demand from emerging countries and first-time wireless subscribers will continue to drive growth for mobile phones. In 2005, the largest share of shipment growth is expected to come from emerging countries, with the total expected volume increasing by more than 20 million units shipped. NV

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Solutions That Work

Electronics Q&A

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist.

Feel free to participate with your questions, comments and suggestions.

You can reach me at:

TJBYERS@aol.com

What's Up:

In-depth look at relay and transistor design/selection. For you valve audiophiles, a circuit for pure DC filament voltage. On the fun side, we have a garden train throttle and two sun chasers. Look for more relay stuff in reader Mailbag. Finally, the Fourth of July is D-day for NASA's comet Deep Impact.

Relay Diodes Explained

Q I read your April 2005 column about EMF suppression. I work with pinball machines, so I'm familiar with the diode across the solenoid coils to prevent high-voltage kickback. What I fail to understand is where the current flow is when the field is collapsing. I understand that no current flows through the diode when the switch or transistor is closed. But when the switch opens or the transistor turns off, why exactly does the current go through the diode? Where does that current flow? How does this prevent it from flowing back towards the transistor or switch? When I try and grasp this, all I can think of is the current going around in a circle!

—Terry Cumming

A Like a capacitor, an inductor is an energy storage device. When you apply voltage across an inductor, a current starts to flow and slowly rises to a steady level (actually, an exponential curve that levels off after about five time periods expressed as 5 x (t = RL)). The relationship of voltage to current verses time gives rise to a property called inductance. The higher the inductance, the longer it takes for a given voltage to produce a given current.

The changing current produces an increasing magnetic field — Figure 1, which, in turn, stores energy in the inductor. When the voltage is removed, current ceases to flow and the magnetic field collapses. This magnetic-field movement cuts through the windings of the coil and generates a voltage across the inductor — with a reverse polarity to the "charging" voltage. The magnitude of the voltage is proportional to the rate of the field collapse. The faster the magnetic lines cut through the windings, the higher the voltage — which can reach voltage spikes 10 times that of the operating voltage.

Unless this high voltage is tamed, it will exceed the voltage rating of the driving circuitry (transistor, IC, mechanical switch). A good way to dissipate this high-voltage energy is to place a diode across the coil. When the switch is on, the diode is reverse biased (doesn't conduct) and the relay engages. When the switch is off, voltage is removed and the field collapses. This forward biases the diode, which now conducts.

Where does that energy go? It's dissipated as heat through the resistance of the coil's windings at a rate determined by t = RL (notice the symmetry?). In essence, the current does go around in a circle. The problem is that the reverse current flow sustains the magnetic field, which prevents the relay from dropping out until all the energy is spent. Hence, the alternative solutions I published in the April column.

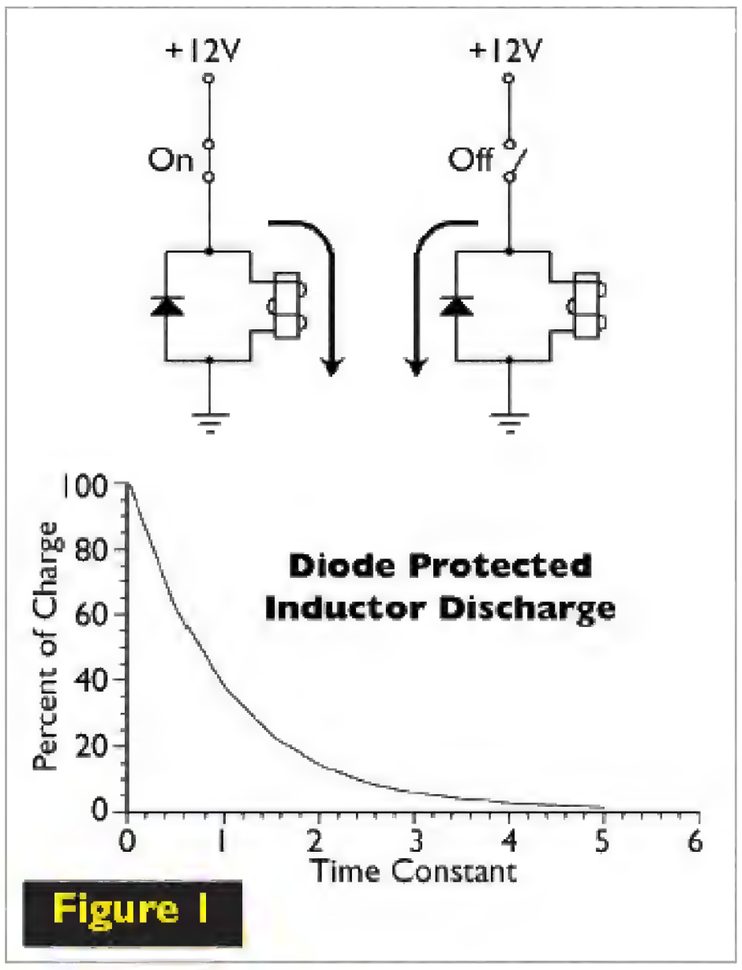


Figure 1

Q&A

Semiconductor Sex Explained

Q. Can an NPN transistor be wired as a PNP transistor? Is it a matter of reversing connections?

— Leonard Mary Thomas

A. NPN and PNP transistors are interchangeable if you remember one simple rule: A bipolar transistor is essentially two back-to-back diodes with the base being the common connection. For a transistor to work, one diode is forward biased and the other is reverse biased. Let's take the common-emitter amplifier in Figure 2, for example. On the left is an NPN (negative-positive-negative) transistor and on the right is a PNP (positive-negative-positive) transistor. Notice that both circuits are identical — except for one thing. The polarity of the power supply is reversed.

In the NPN configuration, the emitter (the lead that looks like the arrow of a diode, labeled E) goes to negative (ground). The base (B) goes to +V via the Rb resistor. This forward-biases the base-emitter diode, which exhibits the characteristic 0.7 volts voltage drop. The collector (C), on the other hand, goes to +V — in effect, reverse biasing that diode.

The breakover voltage of this diode is the VCE parameter listed on the spec sheet, and varies from one transistor type to another. The current through the collector-emitter path is controlled by the current flowing through the base-emitter junction. The amount of influence is called the gain of the transistor, or hFE.

Substituting a PNP in the circuit reverses the current flow through the base-emitter diode and the voltage on the collector. Bottom line, most small-signal amplifiers will work equally well if you replace an NPN with a PNP and reverse the power supply polarity. And that means if you have mixed sexes, each and every transistor has to have a sex change. Please note, I said most — not all — amplifiers will work with this exchange. (Electron and hole mobility are not equal, especially at higher frequencies.)

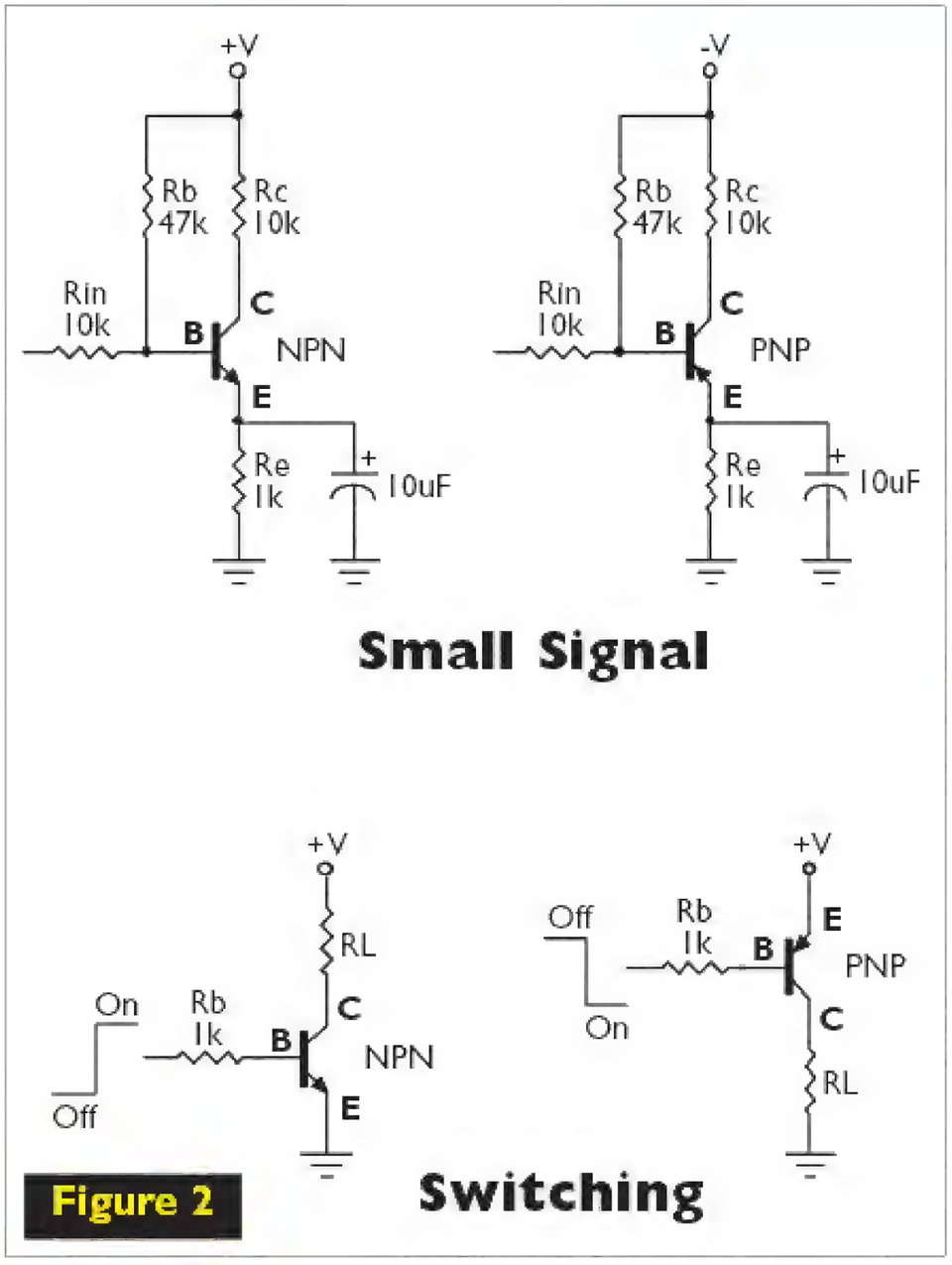


Figure 2

If your application is for logic switching, all you need to do is exchange the emitter and collector in your design so that the forward/reverse bias rule is maintained, as shown in the two bottom circuits. The catch is, when you change sexes, you also change logic. In the NPN configuration, a logic HIGH turns on the transistor. In the PNP version, a logic LOW turns on the transistor. Make sure you adjust accordingly.

A history note. When I was a tyke and new to transistors — having cut my teeth on voltage-controlled vacuum tubes — I heard about this back-to-back diode transistor analogy — and tried to build one myself using 1N34A diodes. Guess what? Didn't work.

The secret to the transistor's transconductance is the tiny gap between the collector and emitter called the base that controls the current flow through the transistor. A gap so small that it took nearly six years between 1948 and 1953 to perfect the first reliable commercial transistor: the CK722.

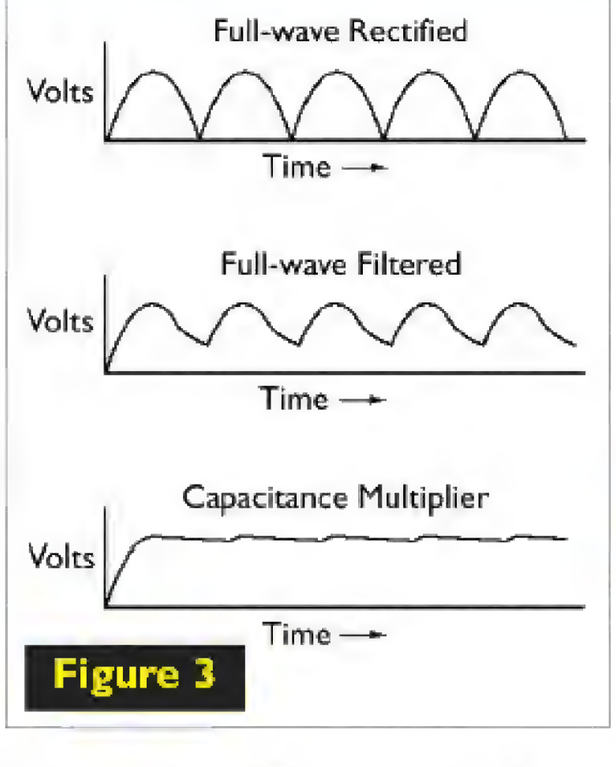


Figure 3

Ripple Wrinkle

Q. I wish to convert the 6.3 VAC heater voltage in my EICO HF-32 tube amplifier from AC to DC. I started with a full-wave bridge rectifier (no center-tap) of the power transformer, then connected two 1,000 uF caps in parallel for filtering. I stopped at this point to take some measurements, which was approximately 9.5 volts DC with 2 mV AC ripple with no load.

This is fine and good and agrees with theory. But when I connected the heaters, the voltage dropped to 5.3 volts DC and the ripple increased to 2 volts AC! I can understand the DC drop of an unregulated supply, but I'm baffled as to the ripple increase. If anything, it should decrease! Any ideas on the ripple increase?

— John Agugliaro, CET

A. Sorry, but you have it backwards. The more current you draw, the greater the ripple. How come? When AC voltage is full-wave rectified, you get a bunch of peaks with very deep valleys — think the Grand Tetons (Figure 3). When you place a capacitor across this ripple, it charges to the peak voltage, then discharges in the valley. The discharge rate of the capacitor is proportional to the load resistance; i.e., the output current. The more current you draw, the faster the filter cap discharges — and the greater the ripple.

For one volt of ripple at one amp you need 8,300 uF. For example, one volt of ripple at 500 mA is 8,300/2 or 4,150 uF. To reduce the ripple to 10 mV at 3.5 amps, you need 2.9F (yes, farads!). As you can see, your 2,000 uF cap combo is a pathetic attempt at filtering the DC. One solution is to use a supercap. But they are rated at just 2.5 volts, which means you'll

need four 10F supercaps in series — with balancing resistors. This will cost you about $20.00, minimum.

A better solution for this application is a capacitance multiplier. The key component (Figure 4) is C2, whose capacitance is directly proportional to the DC gain (hFE) of the transistor. The TIP120 typically has a gain of 2,500 at four amps. Let's say you want a maximum ripple of 2 mV. Plugging the numbers into the 8,300 uF thumb rule, we need 14.5F. Divide that by the 2,500 gain of the TIP120, and C2 equals a small 5,800 uF. I'd use a 6,300 uF, 10V electrolytic. The input and output caps are used to compensate for temperature-related swings in the hFE.

Better Than a Banana Split

Q. I download a lot of executable files (EXE) from an Internet cafe. My problem is sometimes it doesn't fit on a 3.5" floppy diskette. Is there a software program that can chop large files into 1.4 MB segments that will fit on a floppy and be reconstructed to its original single file when transferred to a hard disk?

— Unsigned

A. Try GSplit from G.D.G. Software (**www.gdgsoft.com/gsplit**). I've never used it, but I've heard good things about it.

Reader feedback: *GSplit is great! Thanks a lot.*

Thomas the Tank Engine

Q. I have a 28-volt, 15-amp switching power supply that I would like to use for my 36-inch Garden Railroad. To do this, I need to vary the voltage to the tracks. Can you show me a schematic that would use, say, some 2N3055 transistors and a pot? The locomotive doesn't need any kind of pulse power. I just want to control the power to the tracks to control the speed of the trains. The voltage would vary from zero to the max of the supply at up to 12 amps.

— Emilio Tancredi
Dumont, NJ

A. Oh, but you do want pulse power. Pulse modulation eliminates heat that would otherwise be generated by a linear voltage controller. That's because the switching transistor is either fully on or off. The linear controller, on the other hand, has the transistor acting like a resistor. If the linear transistor is passing 12 amps with a voltage drop of 14 volts (half power to the tracks), it must dissipate 168 watts of heat — more than a 150W floodlamp. A pulse-modulated controller would generate about a watt at the same 50% speed setting. Moreover, you'll get smoother throttle response.

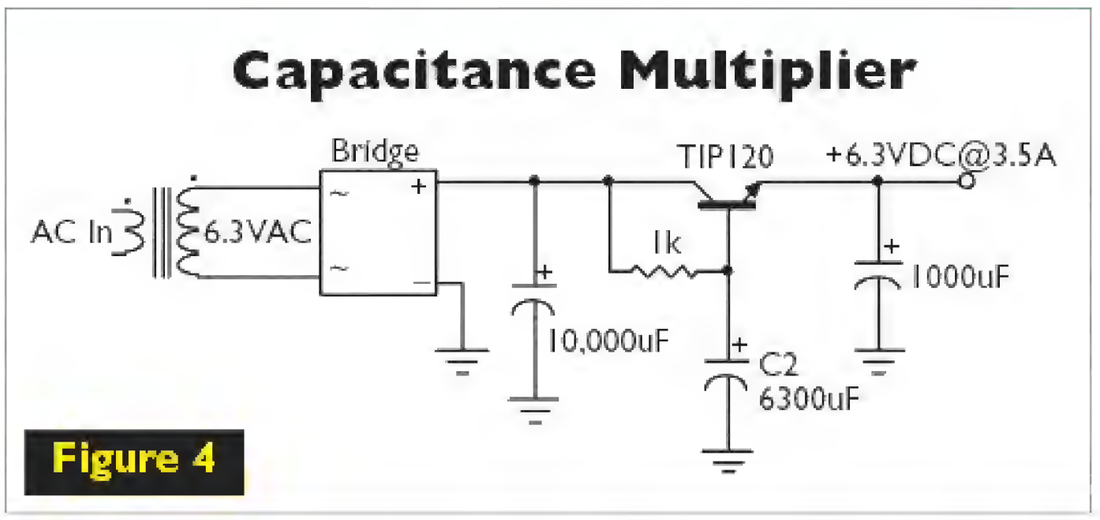
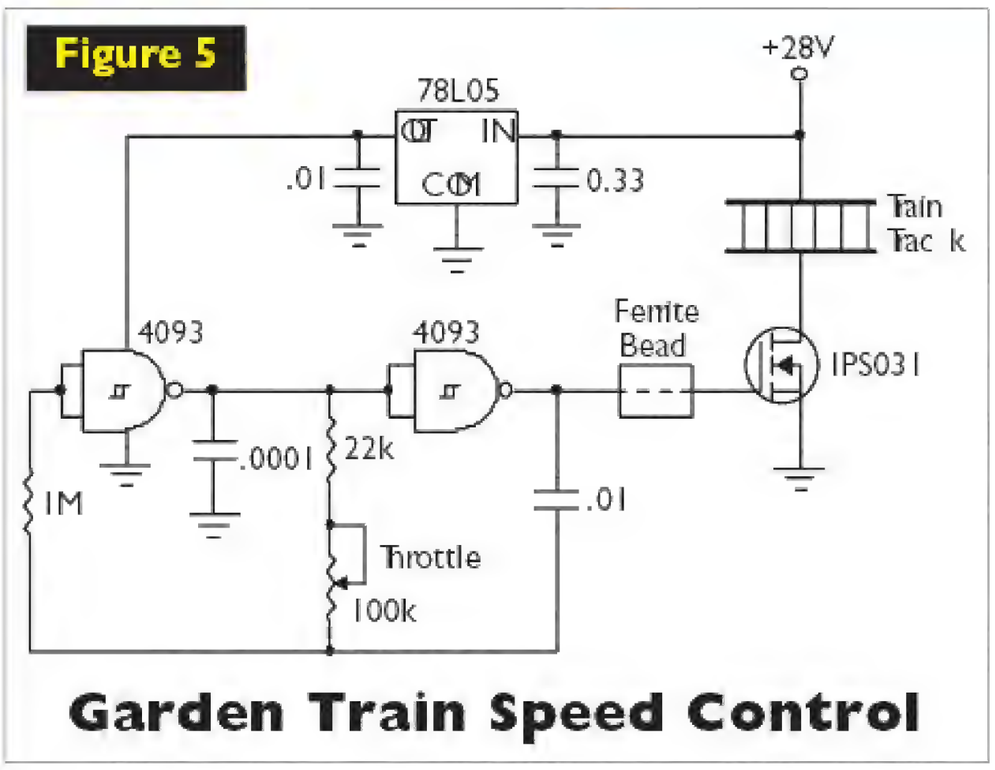


Figure 4

The circuit in Figure 5 is a down-and-dirty design that works best on larger motors — like the ones I'm sure your locomotives sport. The frequency varies in step with the duty cycle, and there's a bit of a "chirp" as the dial approaches top speed (90%) — which can be minimized by fine-tuning the .0001 capacitor. Critical to the design is the smart IPS031 "Smart" FET. This device is optimized for peak performance and reliability in harsh auto environments, and is enhanced to handle inductive loads —



Garden Train Speed Control

especially motors.

Follow the Sun

Q. I'd like to incorporate a photocell to the attached 4017 LED chaser circuit in order to turn it on during daylight and off at night. A variable pot would be nice to control the turn-on threshold, and I would like to power it up from a single three-volt button battery (like a CR2032). I've built this circuit under a microscope and used tweezers to solder all of the SMD parts, so you can see that a relay would be prohibitive. Can this be done?

J. Smith

A. The circuit you sent uses a 555 oscillator, which won't work down to three volts. You could use a ZSCT155, which operates down to 0.9 volts, but it draws a hefty 100 uA at idle. I would use a 4093 Schmitt trigger that draws a mere 0.25 uA at three volts (Figure 6). One gate generates an adjustable-frequency square wave to clock the 4017 decade counter. The photocell controls a second gate that goes low when light falls on the photocell. This, in turn, drives a third gate that applies power to the 4017. Because of the low voltage, some LEDs may fail to light in this design. Red, green, and orange should work okay, but the voltage is too low for amber, white, or blue LEDs.

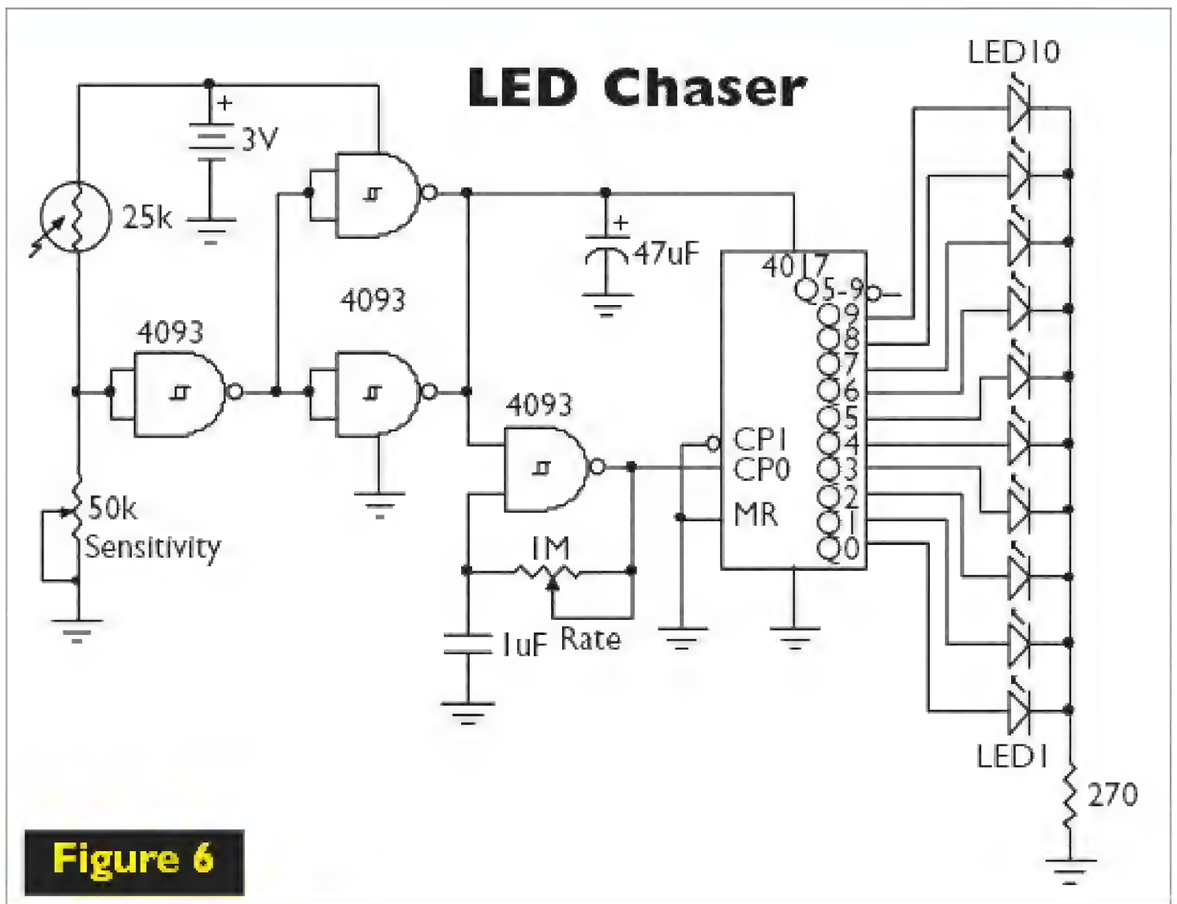


Figure 6

LCD Power Line Monitor

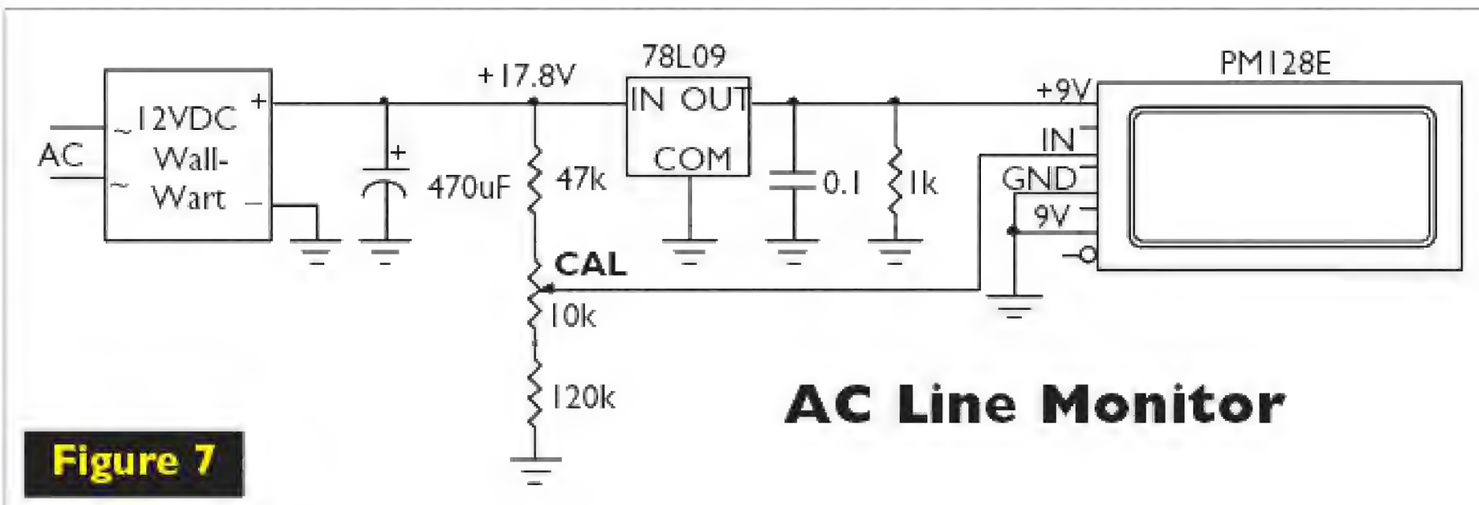
Q. Would it be difficult to change the power line monitor as shown to have a digital readout rather than an alarm? I have measured our power line output with a good quality Fluke meter and it always shows 129 VAC. This seems high, but I don't know what to do about it.

— Frank Lemon

A. A recent Chinese import has made this an easy project. I'm talking about the PM-128E digital panel meter that can be jumper-wire programmed for DC ranges from 200 mV to 500 volts and an AC range of 200 and 500 volts. The meter is available from Circuit Specialists (**www.webtronics.com/panelmeter.html**), and can be used as-is by simply jumpering the 200 VAC solder pads and plugging it into the wall.

However, it is safer to use a small 12-volt wall-wart to isolate the AC line and provide power for the meter. Either an AC or DC wall-wart will work, but using a DC output simplifies the circuit (Figure 7); an AC output requires a bridge rectifier and a 470 uF filter capacitor. Look for an adapter in the 50 mA to 300 mA range with a two-prong input.

Construction is straight-forward. Calibration is done using a DMM or your Fluke — adjust the CAL pot to display the reading on your meter. ALERT! The circuit uses a common ground for the power supply and voltage in. Don't be lured into substituting the one-buck cheaper PM-128 — which requires an isolated power supply — for the PM-128E.



AC Line Monitor

Figure 7

MAILBAG

Dear TJ,

Referring to "Relay Contact Life" in the April 2005 issue: As you know, opening a direct current circuit with a lot of inductance can be notoriously difficult. Forty-seven

years ago, I wired up a large metal working machine with all DC motors and control. The motor that moved a table back and forth had to stop and change direction about every three seconds. I tried several relay arcing fixes — including using capacitors. But what finally cured it was connecting a light bulb across the motor leads. When the motor was energized, the lamp came on; when the motor was stopped, the lamp brightened considerably as it absorbed the inductive decay. All I had to do was try different wattage lamps until the arcing was suppressed.

I was about 23 at the time, out of college with an EE, and working for my father-in-law. One thing he pushed into my head was that simpler was better. So that was why I tried the light bulb trick. The owner of the machine shop was quite impressed. About five years ago, I went back to my home town and visited the owner. He was close to 90 and still active. He had sold the business but retained the right to use the machinery. He took me on a tour of the shop and said that he wanted to show me something. He fired up the old planning mill and there was the same light bulb going on and flaring up before going off.

— Robert E. Robinson

Dear TJ,

Your answer to the question about relay contact resistance measurement (in the May 2005 issue) was interesting, but I believe has a serious flaw. If you had computed the power dissipated at the contacts under the specified conditions [50 milliohms], you would have realized that 1.5 to 3 volts across contacts carrying 30 amps dissipates 45-90 watts. That much power dissipated in such a small space would raise the temperature of the contacts higher than the temperature of the filament of a light bulb, destroying the relay and likely starting a fire.

— Howard Mark
Suffern, NY

Response: *I didn't invent these numbers. They come from datasheets. But your advice is well taken, and a reason why relays fail when contact resistance exceeds a certain limit. And, yes. I have seen my fair share of melted relays. — TJ*

Dear TJ,

About your "Needs Stereo Chips" answer in the April 2005, your answer is perfectly sound. But your reader must not know about Google, because a search was not "fruitless" for me when I was looking for the exact same thing he was seeking.

http://electronickits.com/kit/complete/ampl/k100.htm is a kit for a pre-amplifier that does the exact same thing as the LM1036 does, but is based on the Philips TDA1524A. **www.ramseyelectronics.com/cgi-bin/commerce.exe?preadd=action&key=UAM2** is the Ramsey UAM2, a "class D" audio power amp that works like gangbusters. You CAN still build what your reader wanted from kits.

— Kenneth Tindle
Elect. Technician
Univ. of Kentucky Language Lab

Cool Websites!

NASA Deep Impact will rendezvous with comet Tempel 1 on July 4, 2005. The objective is to shoot a "bullet" into the comet and analyze the debris.
http://link.abpi.net/l.php?20050505A9

Are you fast on the draw? Simply "shoot" five darting sheep with a tranquilizing dart and score your reaction time in milliseconds.
www.bbc.co.uk/science/humanbody/sleep/sheep/

NASA WorldWind — satellite view of the big blue marble.
http://worldwind.arc.nasa.gov/features.html

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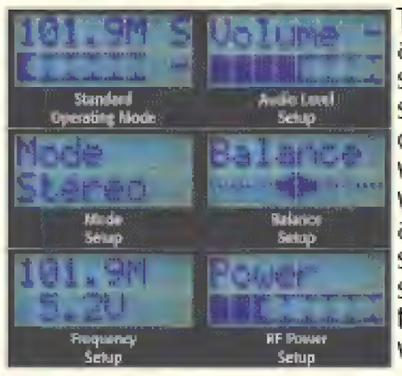
Digital FM Stereo Transmitters

NEW!

- ✔ Rock stable PLL synthesized
- ✔ Front panel digital control and display of all parameters!
- ✔ Professional metal case
- ✔ Super audio quality!
- ✔ 25mW and 1W models!

For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use.

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is available in either white or black. *(Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).*

FM30	**Digital FM Stereo Transmitter Kit, 0-25mW White**	**$199.95**
FM30B	**Digital FM Stereo Transmitter Kit, 0-25mW, Black**	**$199.95**
FM35WT	**Digital FM Stereo Transmitter, Assembled, 1W, White**	**$299.95**
FM35BWT	**Digital FM Stereo Transmitter, Assembled, 1W, Black**	**$299.95**

Professional FM Stereo Radio Station

- ✔ Rock stable PLL synthesized
- ✔ Front panel digital control and display of all parameters!
- ✔ Professional metal case
- ✔ Super audio quality!
- ✔ 25mW and 1W models!

Our FM100B is the updated version of a truly professional frequency synthesized radio transmitter station in one durable, handsome cabinet. It is used all over the world by serious hobbyists as well as churches, drive-in theaters, and schools. No one else offers all of these features at this price! The included frequency display and audio level meters assist in easy operation. The "B" version now includes some additional functionality including a line level monitor output, improved stereo separation, spectral purity, audio clarity, and adjustable RF Output. An exclusive selectable microphone mixer and auto AGC circuit combines your local mic audio with your music input or mutes the music when mic audio is present. You don't even need an external mixer!

Sound quality is impressive; it rivals commercial stations. Low pass input filtering plus peak limiters put maximum "punch" in your audio, and prevent overmodulation distortion. No wonder everyone finds the FM100B to be the answer to their transmitting needs... you will too! The kit includes a sharp looking metal cabinet, whip antenna, and built-in 110/220 volt AC power supply. An external antenna connection allows hook-up to high performance antennas like our TM100 and FMA200. We also offer a high power export version of the FM100B that's fully assembled with one watt of RF power for miles of program coverage. Many islands and villages use it as their local radio station! The export version can only be shipped outside the USA, or within the US if accompanied by a signed statement that the unit will be exported. *(Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body).*

FM100B	**Super-Pro FM Stereo Radio Station Kit, 5uW-25mW**	**$269.95**
FM100BEX	**High Power Version, 5uW-1Watt Output**	**$349.95**
FM100BWT	**High Power Version, 5uW-1Watt, Factory Assembled**	**$429.95**

Professional Synthesized Stereo FM Transmitter

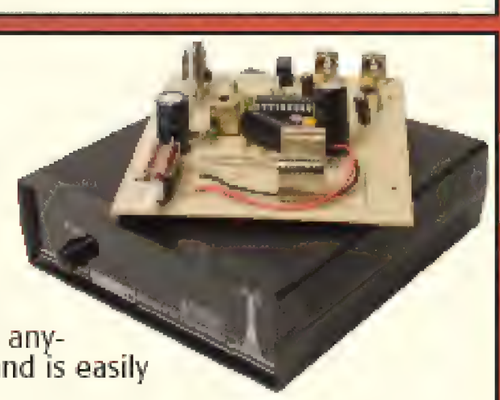
- ✔ Fully synthesized 88-108 MHz for no frequency drift
- ✔ Line level inputs and output
- ✔ All new design, using SMT technology

Need professional quality features but can't justify the cost of a commercial FM exciter? The FM25B is the answer!

A cut above the rest, the FM25B features a PIC microprocessor for easy frequency programming without the need for look-up tables or complicated formulas! The transmit frequency is easily set using DIP switches; no need for tuning coils or "tweaking" to work with today's 'digital' receivers. Frequency drift is a thing of the past with PLL control making your signal rock solid all the time - just like commercial stations. Kit comes complete with case set, whip antenna, 120 VAC power adapter, 1/8" Stereo to RCA patch cable, and easy assembly instructions, and the SMT parts are factory preassembled - you'll be on the air in just an evening!

FM25B	**Professional Synthesized FM Stereo Transmitter Kit**	**$139.95**

Professional Synthesized AM Radio Transmitter



- ✔ Fully frequency synthesized, no frequency drift!
- ✔ Ideal for schools
- ✔ Microprocessor controlled
- ✔ Simple settings

Run your own radio station! The AM25 operates anywhere within the standard AM broadcast band, and is easily set to any clear channel in your area.

It is widely used by schools - standard output is 100 mW, with range up to ¼ mile, but is jumper settable for higher output where regulations allow. Broadcast frequency is easily set with dip-switches and is stable without drifting.

The transmitter accepts line level input from CD players, tape decks, etc. Includes matching case & knob set and AC power supply!

AM25	**Professional Synthesized AM Radio Transmitter Kit**	**$99.95**

Tunable FM Stereo Transmitter

- ✔ Tunable throughout the FM band, 88-108 MHz
- ✔ Settable pre-emphasis 50 or 75 µSec for worldwide operation
- ✔ Line level inputs with RCA connectors

The FM10A has plenty of power and our manual goes into great detail outlining all the aspects of antennas, transmitting range and the FCC rules and regulations. Runs on internal 9V battery, external power from 5 to 15 VDC, or an optional 120 VAC adapter is also available. Includes matching case!

FM10C	**Tunable FM Stereo Transmitter Kit**	**$44.95**
FMAC	**110VAC Power Supply for FM10C**	**$9.95**

Tunable AM Radio Transmitter

- ✔ Tunes the entire 550-1600 KHz AM band
- ✔ 100 mW output, operates on 9-12 VDC
- ✔ Line level input with RCA connector

A great first kit, and a really neat AM transmitter! Tunable throughout the entire AM broadcast band. 100 mW output for great range! One of the most popular kits for schools and scouts! Includes matching case for a finished look! The AM1 has been the leading Scouting project for years and years. Try out your kit skills and at the same time...get on the air!

AM1C	**Tunable AM Radio Transmitter Kit**	**$34.95**
AC125	**110VAC Power Supply for AM1C**	**$9.95**

Tru-Match FM Broadcast Antenna

We've been besieged with calls asking us where to get a good quality FM Broadcast antenna. Remember, matching your antenna to your transmitter is the single most important link in your transmitter setup - and a good antenna and match are the secret to getting maximum range.

- ✔ Fully weatherproof-rugged PVC construction
- ✔ Matches 50 or 75 ohm systems
- ✔ Tunable for a perfect match over the entire 88-108 MHz FM band
- ✔ 25 watt RF power maximum

When we say "match" we mean electrical impedance match... if the proper impedances are not maintained between transmitter and antenna, power is reflected away from the antenna and back into the transmitter! This can cause the final amplifier stage to be damaged, not to mention spurious signals and lousy range. Don't forget, there are three important factors in your broadcast range: antenna, antenna, and antenna! Buy this kit and get the most from your FM Broadcaster!

TM100	**Tru-Match FM Broadcast Antenna Kit**	**$69.95**

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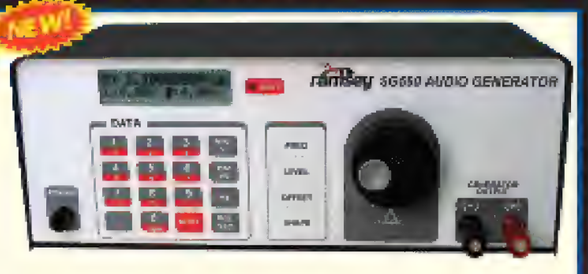
Our Most Popular Kits!

Audio/RF Signal Generator

NEW!



- ✔ DDS and SMT technology!
- ✔ 0 Hz to 5 MHz at 0.1Hz resolution!
- ✔ 0 to 10V peak to peak output level
- ✔ Sine, Square, or Triangle waveform

Following our world famous SG550, we are proud to introduce the SG560, the next generation signal generator!

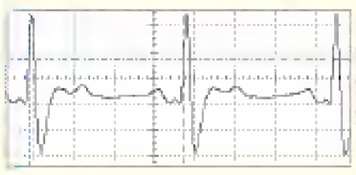
To begin with we increased the frequency range all the way up to 5MHz and all the way down to 0Hz (yes, we mean zero...or DC!) in continuous 0.1Hz steps across the entire range! Then we gave it a variable output level all the way up to 10V peak to peak in either Sine, Square, or Triangle waveforms! You can also provide a DC offset to the output to recreate TTL, 4000 series logic levels, low voltage logic levels, AC waveforms with a DC component, or just plain AC signals!

SMT and DDS technology is used throughout the SG560 for ultimate performance and reliability. If you're looking for a lab quality sig gen at a super hobbyist price, the brand new SG560 fits the bill...and a whole lot more!

SG560WT Audio/RF Signal Generator, Factory Assembled $329.95

Electrocardiogram Heart Monitor

- ✔ Visible & audible display of your heart rhythm
- ✔ Re-usable sensors included!
- ✔ Monitor output for your scope
- ✔ Simple & safe 9V battery operation



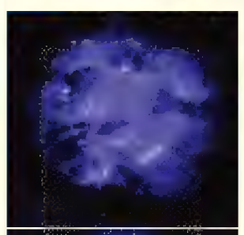
Enjoy learning about the inner workings of the heart while at the same time covering the stage-by-stage electronic circuit theory used in the kit to monitor it.

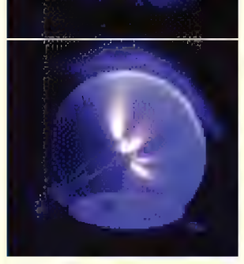
The three probe wire pick-ups allow for easy application and experimentation without the cumbersome harness normally associated with ECG monitors. The fully adjustable gain control on the front panel allows the user to custom tune the differential signal picked up by the probes giving you a perfect reading every time! Multiple "beat" indicators include a bright front panel LED that flashes with each heart beat, an adjustable audio output to hear the beat, and of course, the monitor output to view on a scope, just like in the ER! Operates on a standard (and safe) 9VDC battery. Includes matching case for a great finished look. The ECG1 has become one of our most popular kits with hundreds and hundreds of customers wanting to get "Heart Smart"!

ECG1C	**Electrocardiogram Heart Monitor Kit With Case**	**$44.95**
ECG1WT	**Factory Assembled & Tested ECG1**	**$89.95**
ECGP10	**Replacement Reusable Probe Patches, 10 Pack**	**$7.95**

Plasma Generator

- ✔ Generates 2" sparks to a handheld screwdriver!
- ✔ Light fluorescent tubes without wires!
- ✔ Build your own plasma balls!
- ✔ Generate up to 25kV @ 20KHz from a solid state circuit!





This new kit was conceived by one of our engineers who likes to play with things that can generate large, loud sparks, and other frightening devices. The result... the PG13 Plasma Generator designed to provide a startling display of high voltage!

It produces stunning lighting displays, drawing big sparks, to perform lots of high voltage experiments. In the picture, we took a regular clear "Decora" style light bulb and connected it to the PG13 - WOW! A storm of sparks, light tracers and plasma filled the bulb. Holding your hand on the bulb doesn't hurt a bit and you can control the discharge! It can also be used for powering other experiments; let your imagination be your guide! Can also be run from 5-24VDC so the output voltage can be directly adjusted.

PG13	**Plasma Generator Kit**	**$64.95**
PS21	**110VAC input, 16VAC output power supply**	**$19.95**

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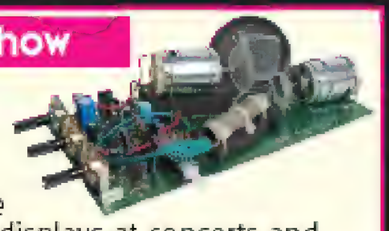
Laser Show



- ✔ What a Light Show!

Just like the fancy laser displays at concerts and theme parks, but inexpensive and fun to build! Uses two small motors, mirrors, and a standard laser pointer as the basics. Front panel controls adjust the pattern and size. PLUS...a line level audio input is included, that automatically modulates the laser pattern to your favorite music! Uses safe plastic mirrors. Runs on 6-12VDC for safe low voltage operation.

LLS1 Laser Light Kit $44.95

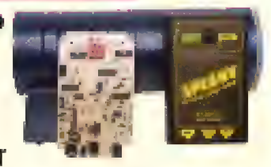
Tri-Field Meter

- ✔ Watch RF, electric, and magnetic fields!

Even Mr. Spock would like this one! 3 separate field sensors provides a cool readout on the two Sci-Fi syled LED bargraphs. You can walk around the house and "see" RF, electrical, and magnetic fields! Uses the latest Hall Effect sensors for super sensitivity. Includes the stylish case set shown. Runs on 4 standard AA batteries, not included. Long long and prosper!

TFM3C Tri-Field Meter Kit $64.95

Speedy Radar Gun



- ✔ YOU be the Cop with your own radar!

One of our most popular science fair projects! Sensitive dopler shift radar provides a digital readout in either Km/Hr, Mph/Hr, or Feet/Sec! Features an 1/8th mile range for average size vehicles. Actual dopler shift can be monitored with the built-in earphone jack. Includes the nifty case set shown, and runs on 12VDC. Uses two standard coffee cans (not provided), so start drinking up!

SG7 Speed Radar Kit $59.95

Ion Generator

- ✔ Generate a breath of fresh air!

Generates negative ions along with a blast of fresh air without any noise! Learn how modern spacecraft use ions to accelerate through space and generate a steady state 7.5kV DC negative at a steady 400uA current. That's a LOT of ions!. Great for air pollution removal in small areas by a simple force if ion repulsion. No fans, motors, blades or noise, just swiftly moving charged air! Runs on 12-15VDC.

IG7 Ion Generator Kit $64.95

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Step up to our PL300, which gives you 300 separate electronic projects along with 165 page learning and theory manual. The PL300 walks you through the learning phase of digital electronics.

If you're looking for the ultimate lab kit, check out our PL500. Includes a whopping 500 separate projects, a 152 page starter course manual, a 78 page advanced course manual, and a 140 page programming course manual! The PL500 covers everything from the basics to digital programming! Learn about electronics and digital technology the fun way and build some neat projects!

PL130	**130 In One Learning Lab Kit**	**$42.95**
PL300	**300 In One Advanced Learning Lab Kit**	**$69.95**
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by James Antonakos

Electronic Theories and Applications From A to Z

Let's Get Technical

Optical Illusion and the Light Emitting Diode

My three-year-old daughter recently became fascinated by a small hand-held electronic toy that spins a disk round and round very quickly (see Figure 1). Light emitting diodes (LEDs)mounted on the edge of the disk turn on and off in all sorts of interesting patterns. Those familiar with my background in electronics will recognize that I cannot stand idly by, watching this $10.00 toy flash its lights at me without beginning to think about how to do it myself.

So, I began studying it when my daughter was not looking. The child in me enjoys watching it anyways, so staring at it for long periods of time was not a problem. Well, I began to see patterns. This was not difficult, since the toy was designed to create lots of different patterns. But when I say "I began to see patterns," I am saying I began to see how the patterns were being created.

Sometimes an LED would stay on, forming a solid colored line as it spun around. The LEDs would take turns switching from off, to solidly on, to pulsating, seemingly at random. The pulsating patterns looked like slowly moving dashed lines.

The lengths of the dashes (and thus the number of dashes present in one rotation of the disk) varied as well, from as few as two to more than 20. Even the rotation of the patterns seemed to change from clockwise to counterclockwise and back (when viewed from above), with each LED doing its own thing.

Okay, how are they doing that, I wondered? After thinking about it for a while, I decided they might be pulse-width modulating the LEDs, playing with the duty cycle of the waveforms turning the LEDs on and off. The direction changes could be due to the out-of-phase timing relationship between the motor spinning the disk holding the LEDs and the sequencing waveform for the LED. At least this is what I think — based on experience, endless hours of physics labs as a student, and an internal hunch.

So, there will be a little mathematics involved during the design process, as the rotational speed of the DC motor is related to the timing sequences used to control the LEDs.

Figure 2 shows a diagram of the device. This drawing is based on a visual inspection of the toy. Without taking it completely apart, I can only wonder where the electronic controller chip is located, but my guess it that it is inside the spinning disk. This is not a Sherlock Holmes type of deduction. If you look closely at the bottom of the disk where it meets the motor shaft, you will see a small metal wiper that makes contact with a round metal band on the disk shaft.

Obviously, you cannot have wires connecting the disk to the base of the unit; they would quickly wrap themselves silly around the shaft. Is the motor shaft itself being used as a conductor to the disk? With only one — or possibly two — visible conductors connecting the disk to the base, it seems unlikely that the controller chip is located in the base of the unit.

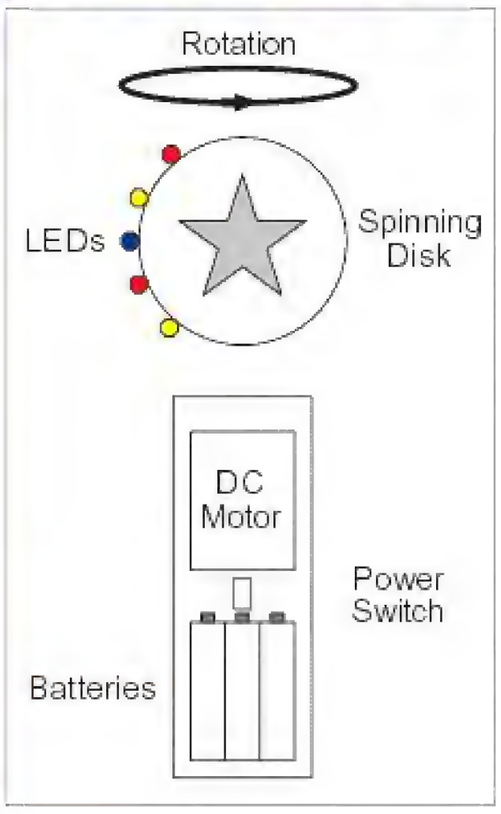
I imagine the controller chip itself having at least seven pins: two for power and ground, and five for the five LEDs on the disk. Maybe the controller chip is a microcontroller, maybe it is an ASIC (Application Specific Integrated Circuit). Does it have intelligence just because it enables lots of patterns?

I am awaiting the arrival of a newly minted microcontroller development board. The light disk is going to be the first project I develop for it. This sure seems like a lot of trouble to go through just to create a pleasing optical illusion. Especially when you can just go buy the toy for $10.00. But when you do that, you rob yourself of the joy of discovery, the pride of creating something new, and the lessons learned designing, troubleshooting, and testing your creation.

Next time, we will walk through the design process and bring this device into existence. NV

Figure 1. Hand-held electronic toy that creates many different optical patterns on five colored LEDs as they spin around.

Figure 2. Diagram of the electronic toy.



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My electronic hobbies are fun again!"

Check out that Jameco Smile!

Order what you need anytime. With overnight delivery, 24/7 ordering, and 99% in-stock availability, their knowledgeable staff gets me what I need when I need it. By shopping with Jameco there's no more parking hassles and endlessly searching aisles. Now I can spend more time developing my ideas rather than searching for parts.

LOWEST GUARANTEED PRICES

The nice thing is, Jameco carries high-quality electronic components and guarantees the lowest prices. If I were to find one of their parts priced lower in another print catalog, Jameco would beat that price by 10%, right down to their cost!

Jameco is unique - they know what I need. And that's what matters most. Try them and you'll see why.

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Circle #40 on the Reader Service Card.

by Jon Williams

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

Stamp Applications

Getting Hot, Hot, Hot

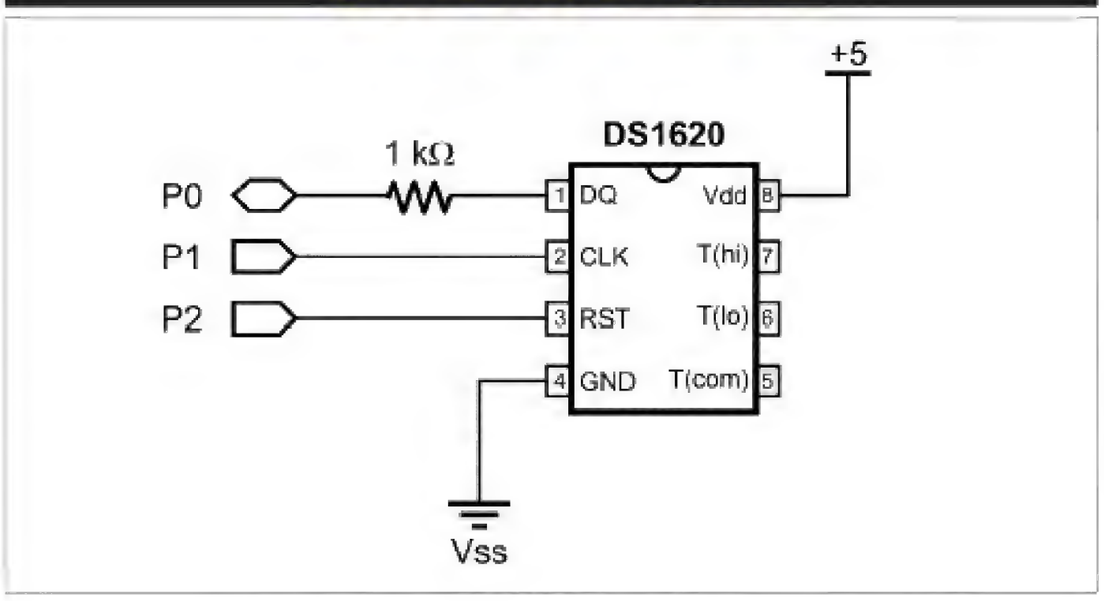
I think it's fair to say that my friends would tell you I'm a bit of a quirky guy. I accept that; I am what I am. One of my many quirks — one that makes me laugh at myself — is how freakishly sensitive I am to temperature. I probably adjust the thermostat in my home 15 to 20 times a day — and that includes the night, too (if I have to get up for a drink of water, I'm visiting the thermostat). Well, now that it's summer in north Texas, it's getting hot (as it is in most of the northern hemisphere) and it's probably time for more experiments with temperature.

Like the BASIC Stamp, the Maxim/Dallas DS1620 has been around a long time and has been a big part of my temperature-based projects. Yet in all this time, I had never explored the high-resolution use of the DS1620. "High resolution?" you ask. Yeah. With just a little bit of extra work, we can get temperature resolution to 0.05 degrees Celsius (0.09 degrees Fahrenheit) from our old stand-by. How is this possible?

You see, the DS1620 actually measures temperature through the use of a couple temperature-controlled oscillators that drive a counter. When one oscillator rolls over within the period determined by the other oscillator, the temperature count is incremented (from the base of -55C). The key for us is that the fractional portion of the temperature can be determined by examining the count left over at the end of the conversion period and comparing it to the number of counts per degree (called the slope – this value is used to linearize the natural non-linear behavior of the oscillators).

Before we get to the high-resolution calculation, let's go back to what we know and use the standard calculations first. What we will do differently is configure the DS1620 so that it converts temperature only when requested (we've typically set it up for continuous conversion), and we'll recode for PBASIC 2.5 — which you'll see makes things dramatically easier than before. Figure 1 shows the connections to the DS1620. For those of you that are new, don't leave the 1K resistor out of the circuit. The DQ pin is bi-directional and the resistor protects the BASIC Stamp and the DS1620 in the event that both IO pins are made outputs and driven in opposite directions (one high, one low — which would cause a short circuit without the resistor).

Figure 1. DS1620 Connections.



Let's get to the initialization. As you can see, it's simpler than what we've used in the past as we're just configuring for use with a CPU and in one-shot mode. We start by activating the DS1620 (Reset pin is made high), then writing %11 to the configuration register. When that's done, we can deactivate the DS1620 by taking the DS1620 low.

```
Setup:
  HIGH DsRst
  SHIFTOUT DsDQ, DsClk, LSBFIRST, [WrCfg, %11]
  LOW DsRst
  PAUSE 10
```

Just a note on the DS1620 Reset pin: It does more than select the device we're addressing; it also terminates a communication "burst" with the host. I bring this up so that you don't think you can tie that line high when you're just using one DS1620 in a project.

Okay, you may notice that the program doesn't run correctly the first time — we have to cycle power for the new configuration to "take." Now that we've configured the DS1620 for one-shot mode, let's start a temperature conversion.

```
Get_Temp:
  HIGH DsRst
  SHIFTOUT DsDQ, DsClk, LSBFIRST, [StartC]
  LOW DsRst
```

How do we know when the conversion cycle is done?

Well, we could take the easy way out and just pause for about a second, but the DS1620 will actually tell us when it's finished.

```
DO
  HIGH DsRst
  SHIFTOUT DsDQ, DsClk, LSBFIRST, [RdCfg]
  SHIFTIN DsDQ, DsClk, LSBPRE, [tempIn\8]
  LOW DsRst
LOOP UNTIL (tempIn.BIT7 = 1)
```

The end of the temperature conversion cycle is signaled by bit 7 of the configuration register. What this loop of code does is read that register until bit 7 goes high. Here's a great example of how PBASIC 2.5 features make BASIC Stamp programming so much more elegant.

When the conversion is complete, we can read the temperature just as we've done in the past:

```
HIGH DsRst
SHIFTOUT DsDQ, DsClk, LSBFIRST, [RdTmp]
SHIFTIN DsDQ, DsClk, LSBPRE, [tempIn\9]
LOW DsRst
```

And, finally, we can calculate the temperature to 0.5 degrees Celsius resolution:

```
IF (sign = 0) THEN
  tC = tempIn * 5
  tF = tC * 9 / 5 + 320
ELSE
  tC = tempIn | $FF00 * 5
  tF = 320 - ((ABS tC) * 9 / 5)
ENDIF
```

Remember that the DS1620 returns a nine-bit temperature value, and that the LSB (bit 0) is equal to 0.5 degrees Celsius. The first thing to check is the sign bit (bit 8) — when this bit is one, the temperature is negative. In most of our projects it won't be, so let's start at the top. We multiply the value returned by the DS1620 by five to convert the temperature into tenths. So, if the temperature is 23.5 degrees C, we'll end up with 235 in the variable tC. Now we can convert to Fahrenheit using the standard formula F = C x 1.8 + 32. As we're working in tenths, we have to multiply 32 by 10 as well, to keep things intact. Now, let's look at handling negative temperatures (when bit 8 of tempIn is 1). First, do this in your BASIC Stamp editor:

```
DEBUG IBIN16 -55
```

Some will be surprised by the result: %1111111111001001. The reason for this is that the BASIC Stamp stores negative numbers in two's-compliment format. So does the DS1620. The thing is, the DS1620 only returns nine bits, so we have to "fix" that by setting the upper bits of tempIn before moving on with the rest of the calculations. We do this by ORing tempIn with $FF00.

Another thing to note is that we cannot use division with negative values, hence the use of **ABS** (absolute value) in the Fahrenheit calculation. Using the **ABS** function makes the tC value positive in the calculation, so adjust by subtracting the tC portion from 320 — cha-ching,

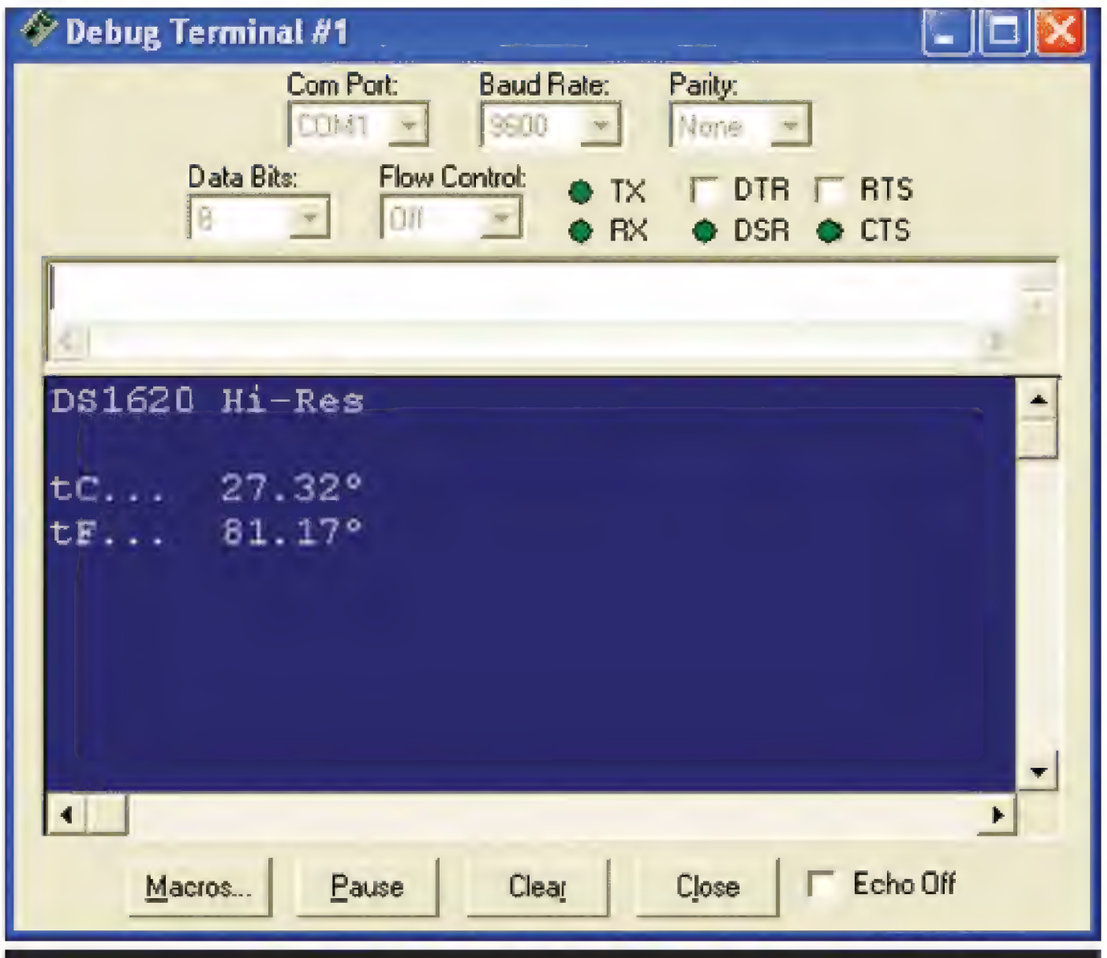


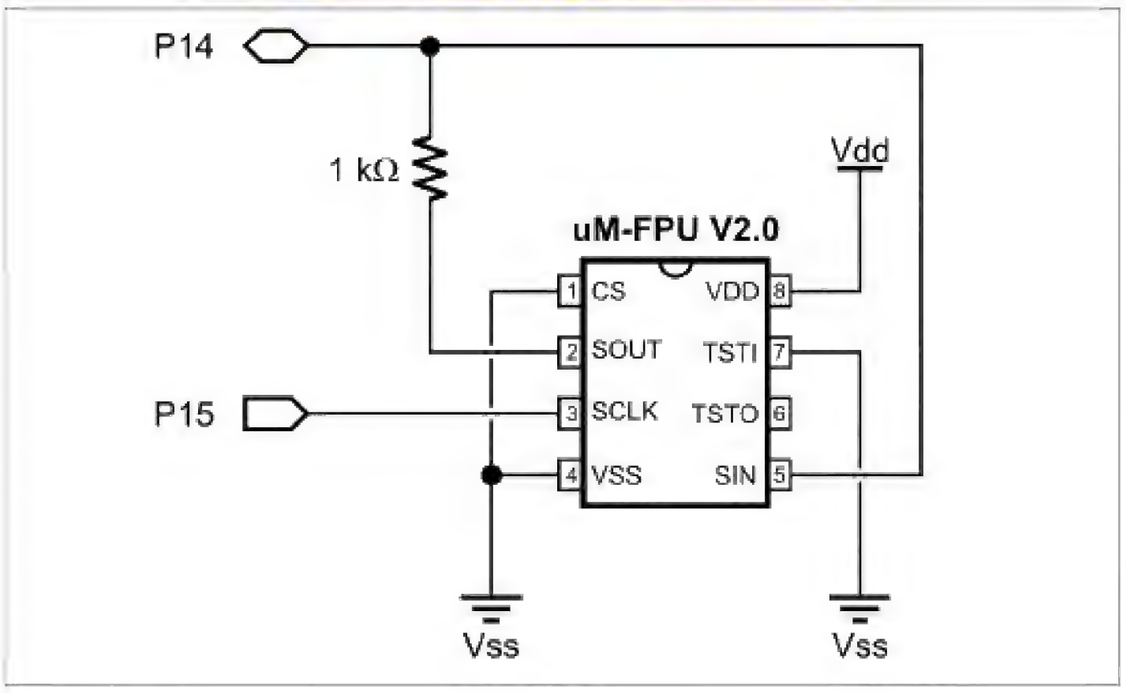
Figure 2. DS1620 High-Res Output.

everything is correct now. Finally, let's put the temperature up in the Debug Terminal window:

```
Show_C:
 DEBUG CRSRXY, 6, 2,
        (tC.BIT15 * 13 + 32),
        DEC (ABS tC / 10), ".", DEC1 (ABS tC),
        DegSym, CLREOL

Show_F:
  DEBUG CRSRXY, 6, 3,
        (tF.BIT15 * 13 + 32),
        DEC (ABS tF / 10), ".", DEC1 (ABS tF),
        DegSym, CLREOL
```

This code starts by examining bit 15 of the value — when bit 15 is one, the value is negative. From this bit, we create a negative sign or space (when positive) to precede the value. The rest is simple; we'll divide the [absolute] value by 10 for the whole portion, print a decimal point, and then use DEC1 for the final digit to display the tenths.

Figure 3. uM-FPU Connections.



Going Higher

To get high-resolution temperature from the DS1620, we will proceed as before and then read two additional values: the count remaining and the slope. To do this, we will add the following code after reading the temperature value:

```
HIGH DsRst
SHIFTOUT DsDQ, DsClk, LSBFIRST, [RdCntr]
SHIFTIN DsDQ, DsClk, LSBPRE, [cRem\9]
LOW DsRst

HIGH DsRst
SHIFTOUT DsDQ, DsClk, LSBFIRST, [RdSlope]
SHIFTIN DsDQ, DsClk, LSBPRE, [slope\9]
LOW DsRst
```

The first section reads the count register, the second reads the slope accumulator. With these values, we can calculate high resolution temperature with this equation:

tC – 0.25 + (slope – counts) / slope))

Note that tC in the equation above is the whole value from the DS1620 – the half-bit is dropped (as this was determined by estimation inside the DS1620). Here's how we implement the high-resolution calculation resolution in PBASIC:

```
IF (sign = 0) THEN
  tC = (tempIn / 2) * 100
  tC = tC - 25 + (slope - cRem * 100 / slope)
  tF = tC * 9 / 5 + 3200
ELSE
  tC = (tempIn / 2) | $FF00 * 100
  tC = tC - 25 + (slope - cRem * 100 / slope)
  tF = 3200 - ((ABS tC) * 9 / 5)
ENDIF
```

In order to deal with the 0.25 value in the equation, as well as take advantage of the increased resolution offered, everything is converted to hundredths. Other than that, you can see that the calculation is quite straightforward and with an adjustment to our display code (for hundredths), the output we get looks like that in Figure 2.

A Little Help from a Friend

That was actually pretty easy, wasn't it? What about those times when we have a sensor that requires complex calculations to convert its raw output to something we can use? After I was satisfied with the hi-res version of the DS1620 program, I took note of the Micromega Corporation uM-FPU (V2.0) chip sitting on my desk. This device — kindly sent to me by Cam Thompson — is a floating-point math coprocessor that is designed to assist small micros like the BASIC Stamp. I've had the thing for several months; I thought it was time to give it a whirl.

Following my own frequent advice, I cracked open the uM-FPU docs and read through them. Holy smokes, Batman, this little dude is a handful!. After my first read, I thought my eyes were bleeding and my brain had

exploded! Okay, all kidding aside, it's not terribly complicated, but it is very sophisticated and if one doesn't proceed deliberately, things can get out of hand in a big hurry.

Think about it, the uM-FPU is a coprocessor for floating-point mathematics — something that we all [should] know is NOT a trivial process. Floating-point requires a gigantic amount of processor resources; hence, most micros don't have FP built in. In fact, it wasn't all that long ago that our PC processors started coming with FP built in. Many of us remember the good old days when we had to crack open our PC to add a floating-point coprocessor (my first was an 80287 for my IBM PC Model 50) to speed up math-intensive applications like CAD.

Using a coprocessor for a small micro like the BASIC Stamp makes sense to me — most of my projects do not require FP math, so why waste the resources when I can add FP only when needed? But that's just my opinion, and I know that many of you think differently. For those that are looking for a way to add FP math to your BASIC Stamp projects, we're going to work through converting our DS1620 project for use with the uM-FPU. Now, I will admit without reservation, that this project is not even coming close to scratching the surface of capabilities of the uM-FPU; but it will get you going, and will prepare you for more complicated tasks.

Figure 3 shows the connections for the uM-FPU using SPI mode. The uM-FPU is fairly flexible in its connections and has separate input and output data pins (SIN and SOUT) for micros that can't use the same IO pin for input and output. Since the BASIC Stamp can do that without any problems, we simply put a 1K resistor between those pins to prevent any conflicts. Notice that the uM-FPU has a CS pin. This is not a Chip Select as we might first assume. What this pin actually does is configure the communication mode of the uM-FPU. When tied low (as we're doing), the uM-FPU uses SPI communications; when tied high, it uses I2C communications (yes, clock and SIN/SDA must be pulled up). The latter mode is convenient when using the BS2p family and when there's already an I2C bus in the project.

Getting to the meat of things, the uM-FPU is a processor with its own language. Briefly, the device uses 16 32-bit registers to hold values, and two pointers (A and B) to direct the operations. If, for example, we wanted to multiply register 1 by register 2, then add register 3 and place the result in register 4, the uM-FPU instructions would look like this:

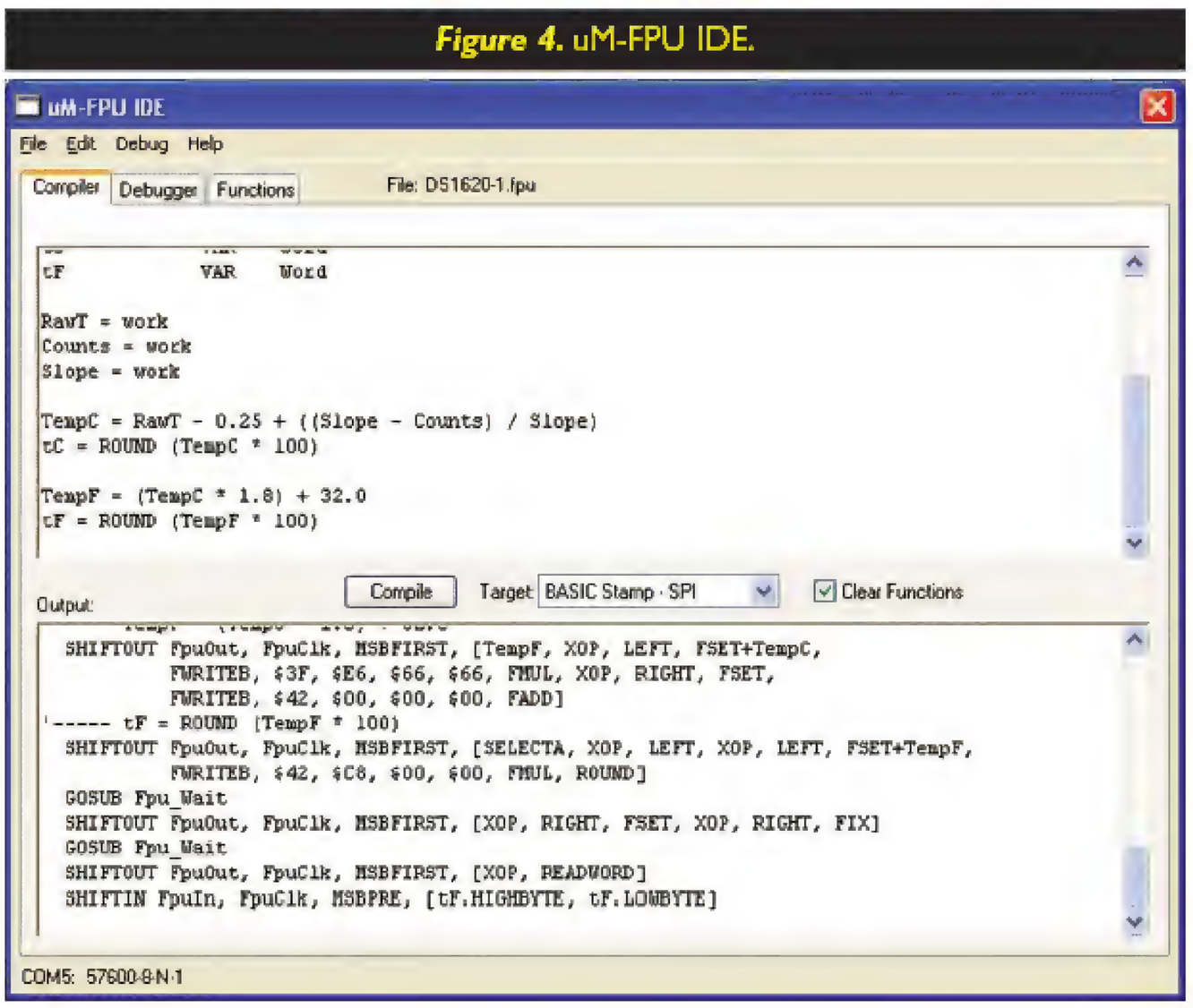
```
SELECTA+4
XOP, LEFT
FSET+1
FMUL+2
XOP, RIGHT
FSET
FADD+3
```

I don't know about you, but my plate is pretty full and I really don't have time to learn an arcane language for a chip that I wouldn't use very frequently anyway. I nearly scrapped the idea of using the uM-FPU until I remembered a comment in the docs about an IDE for the uM-FPU. And since Cam was kind enough to send me the chip, I thought I should at least give that a look before walking away.

Hallelujah! What a difference a simple program can make in my attitude toward the uM-FPU! The IDE makes it so we don't have to learn the uM-FPU language — it will take very traditional looking code and covert it to uM-FPU instructions for us. The program even lets us select the compiled output format, including the BASIC Stamp running is SPI mode. Now we're talking! So, before you get too involved in the uM-FPU programming commands, download the IDE and give it a try – it will save you hours of frustration. Figure 4 shows the IDE with the first pass DS1620 code loaded up. You can see our input in the top window and the compiled output (set for BASIC Stamp SPI) in the bottom window. Let's look at the input code.

```
RawT            EQU     F1
Counts          EQU     F2
Slope           EQU     F3
TempC           EQU     F4
TempF           EQU     F5

work            VAR     Word
tC              VAR     Word
tF              VAR     Word

RawT = work
Counts = work
Slope = work

TempC = RawT - 0.25 + ((Slope - Counts) / Slope)
tC = ROUND (TempC * 100)

TempF = (TempC * 1.8) + 32.0
tF = ROUND (TempF * 100)
```

Figure 4. uM-FPU IDE.



As with any other program, we start by defining storage space — in this case, we're going to name the floating point registers required, as well as our own PBASIC variables. By using our PBASIC variables in the uM-FPU IDE code, the output will be ready to paste right into our BASIC Stamp application.

After the definitions, we have to transfer data from the BASIC Stamp to the uM-FPU. Since we're now using internal registers, we can use a single variable (called work) in our BASIC Stamp code. We'll see how all this meshes in just a bit. With the raw values in place, the calculations match what we find in the DS1620 docs. Now remember that the BASIC Stamp uses integers, so what we'll do is convert the temperature to hundredths and then to fixed point (with ROUND) before going back to the BASIC Stamp.

After clicking on the Compile button, we'll have code that is ready to paste into our BASIC Stamp program. What I should also point out is that the uM-FPU comes with a template program that includes several useful subroutines. What I actually did was add my DS1620 interface to the uM-FPU template to get everything together. I've included both the template and the three versions of the DS1620 program in the download ZIP file at **www.nutsvolts.com**

Our task now is to paste the output code from the IDE into our application where it's needed. For example, this line of uM-FPU code:

```
RawT = work
```

... compiles to:

```
' ------ RawT = work
SHIFTOUT FpuOut, FpuClk, MSBFIRST,
          [RawT, LOADWORD, work.HIGHBYTE,
          work.LOWBYTE, FSET]
```

Remember that we need to truncate the half-degree bit and fix the sign (if required) before sending the value to the uM-FPU. After repeating this process for other raw values, we get to the calculations. To keep things simple, let's just look at the high-resolution Celsius calculation:

```
' ----- TempC = RawT - 0.25 + ((Slope - Counts) /
Slope)
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [TempC, FSET+RawT,
           FWRITEB, $BE, $80, $00, $00, FADD, XOP,
LEFT,
           XOP, LEFT, FSET+Slope, FSUB+Counts, XOP,
RIGHT,
           FSET, FDIV+Slope, XOP, RIGHT, FADD]
```

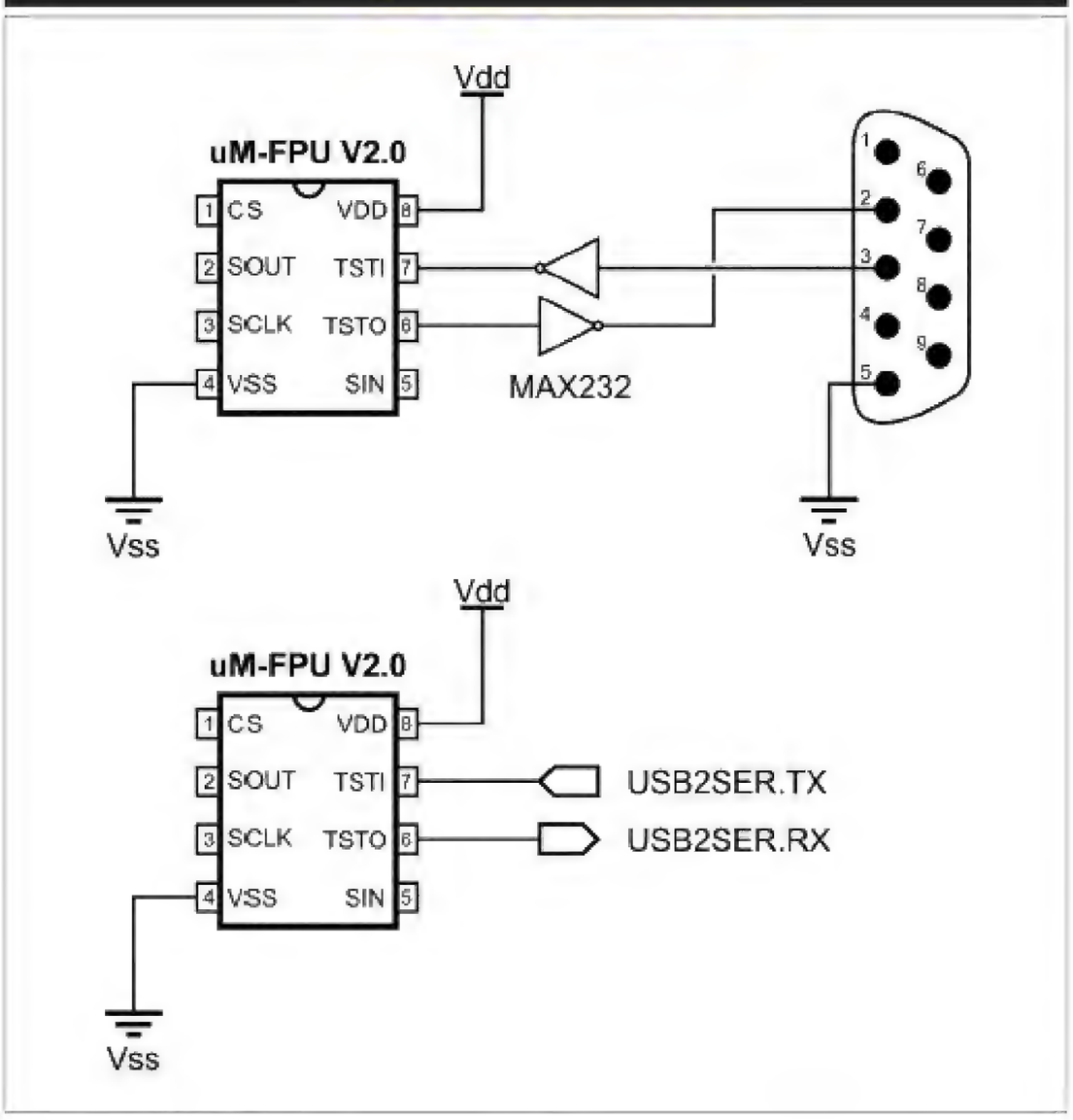
Wow, that's a mouthful, isn't it? You can see why the uM-FPU IDE is such a Godsend — I'd hate to have to figure this out on my own. But wait, we're not done — we've still got to convert the temperature to hundredths, back to fixed point, and pull it back into the Stamp.

```
  ' ----- tC = ROUND (TempC * 100)
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [SELECTA]
  GOSUB Fpu_Wait
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [XOP, LEFT, XOP,
LEFT,
           FSET+TempC, FWRITEB, $42, $C8, $00, $00,
FMUL, ROUND,
           XOP, RIGHT, FSET, XOP, RIGHT, FIX]
  GOSUB Fpu_Wait
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [XOP, READWORD]
  SHIFTIN FpuIn, FpuClk, MSBPRE, [tC.HIGHBYTE, tC.LOW-
BYTE]
```

At this point, the variable tC holds the temperature (in Celsius) and we can display it as we did in the original version of the hi-res program. Some of you will [logically] wonder why we would go through so much trouble for calculations that weren't that tough to start with. Well, of course we wouldn't with the DS1620. Remember that our purpose here was to take something we know (DS1620) and use it to help us learn something new (uM-FPU).

I'm sure by now you've also noticed that it does take a fair bit of PBASIC code to execute calculations inside the uM-FPU. And what happens when we want to do something really complicated? Thankfully, Cam thought of that and has provided a solution. You see, another thing the uM-FPU IDE can do for us is download the calculations to the chip. After that, all we have to do is send the raw data, request a specific calculation be executed, then retrieve the desired data. To do this we have to prep the chip by removing it from our application and connecting it to the PC as shown in Figure 5. Since I was using the PDB for my experiments, I used the spare serial port. And as a test, I also connected using the USB2SER adapter and found that it works just

Figure 5. uM-FPU to PC.



fine, too.

The uM-FPU code for embedded calculations changes a bit. Let's have a look.

```
RawT              EQU     F1
Counts            EQU     F2
Slope             EQU     F3
TempC             EQU     F4
TempF             EQU     F5
TempCL            EQU     L6
TempFL            EQU     L7

work              VAR     Word

#FUNCTION 0 Calc_TC
  TempC = RawT - 0.25 + ((Slope - Counts) / Slope)
  TempCL = ROUND(TempC * 100)
#END

#FUNCTION 1 Calc_TF
  TempC = RawT - 0.25 + ((Slope - Counts) / Slope)
  TempF = (TempC * 1.8) + 32.0
  TempFL = ROUND(TempF * 100)
#END

RawT = work
@Calc_TC
work = TempCL
@Calc_TF
work = TempFL
```

Note that we've added a couple fixed point registers (L is for Long, the 32-bit fixed format) to hold the final result of our calculations. And in order to embed and access the temperature calculations, we must define them as functions as shown in the listing. In our case, Function 0 is called Calc_TC and the Function 1 is called Calc_TF.

When you look at the IDE Output box, you'll see that there is no code for the functions; the only thing we have moving is data between the BASIC Stamp and the uM-FPU. Click on the IDE "Functions" tab and you should get something like what is shown in Figure 6. With the uM-FPU connected to our computer, we can click on the "Program Functions" button to move the code into the uM-FPU.

To be honest, I think this is the strongest suit of the uM-FPU. We can preprogram a wide variety of calculations and then call them as required. I like that. This example is simple, but Cam has done some really neat things with the uM-FPU, including the calculations for inverse kinematics for a robot arm!

After the uM-FPU is programmed with the calculations, put it back into the DS1620 project and replace the code that actually performed the high-resolution Celsius calculation with this:

```
  ' ----- @Calc_TC
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [XOP, FUNCTION]

  ' ----- work = TempCL
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [TempCL]
  GOSUB Fpu_Wait
  SHIFTOUT FpuOut, FpuClk, MSBFIRST, [XOP, READWORD]
  SHIFTIN FpuIn, FpuClk, MSBPRE, [tC.HIGHBYTE, tC.LOW-
BYTE]
```

See how much cleaner our program becomes when we store the calculations in the uM-FPU? Yeah, that's the way I like it.

I think that's about enough for this month, don't you? With summer in full swing (and winter for our friends down under), we now have the tools to tell the temperature with much more precision than we've used in the past. And we also have a cool new tool to help us with complex calculations. Be sure to visit the Micromega website for IDE updates and lots of neat application notes for the uM-FPU. Now that you're started, the rest should get pretty easy. Until next time, stay safe, have fun, and Happy Stamping! NV

Jon Williams
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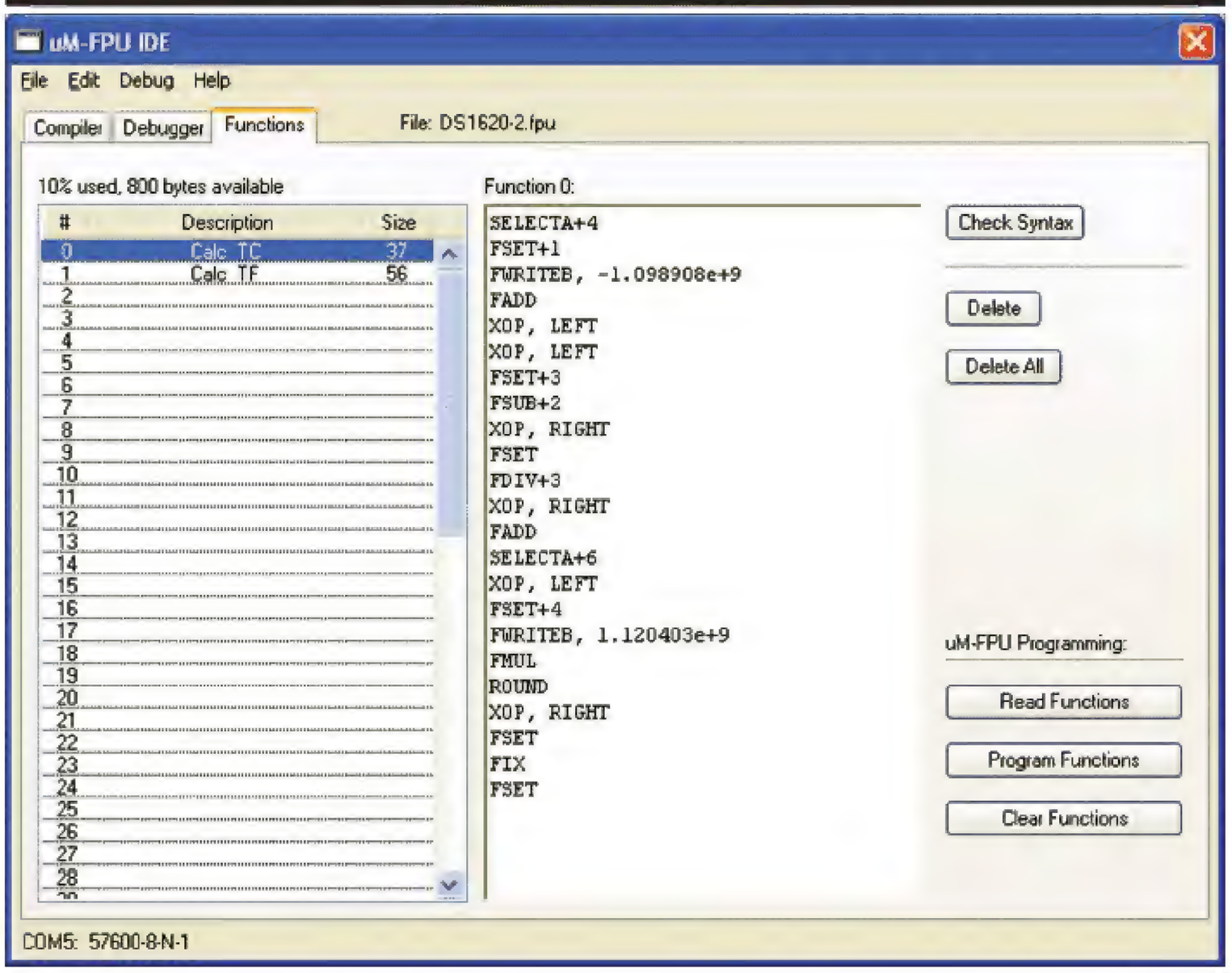
Figure 6. IDE Functions.



HIGH-SPEED USB 2.0 MODULE

ACCES I/O Products, Inc., revealed its newest digital I/O product — Model USB-DIO-32. This USB device is an ideal solution for adding portable, easy-to-install, digital I/O and counter capabilities to any PC or embedded system with a USB port. The unit is a true USB 2.0 device, offering the highest speed available with the USB bus. It is fully compatible with both USB 1.1 and USB 2.0 ports. The unit is plug-and-play, which allows quick connect or disconnect whenever you need additional I/O on your USB port. The USB-DIO-32 can be used in a variety of applications such as home, portable, laptop, education, laboratory, industrial automation, and embedded OEM.

The USB-DIO-32 features 32 lines of TTL-compatible digital I/O on four eight-bit ports with high-current output capabilities and three optional 82C54 counters. Power is supplied to the device via the USB cable or, for higher current applications, an external power option is available.

Unlike other USB digital I/O products, which primarily use a human interface device (HID) driver, ACCES offers an easy-to-use, Windows-based, custom function driver optimized for maximum data throughput. This approach enables the full functionality of the hardware along with maximizing the advantage of using the high-speed USB 2.0 bus.

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- All 32 I/O lines buffered with Sink 64mA/Source 32mA current capabilities
- Custom high-speed function driver
- Removable screw terminal adaptor for easy wiring
- Three optional 82C54 counter/timers
- Rugged industrial enclosure

The USB-DIO-32 is designed to be used in rugged industrial environments, but is small enough to fit nicely onto any desk or testing station. The board is PC/104 sized (3.550" x

Circle #105 on the Reader Service Card.

3.775") and ships inside a steel powder-coated enclosure with an anti-skid bottom. ACCES offers a number of options with the USB-DIO-32 for added flexibility. An economy version is available without the screw terminal adaptor, and the OEM (board only) version is perfect for a variety of embedded applications. The board's PC/104 compatible pre-drilled mounting holes ensure easy installation using standard standoffs inside most enclosures or systems.

The USB-DIO-32 is supported for use in most operating systems, and includes a free Linux and Windows 98/NT/2000/XP/2003 compatible software package. This package contains sample programs and source code in Visual Basic, Delphi, C++ Builder, and Visual C++ for Windows. Also incorporated is a graphical setup program in Windows. Third party support includes a Windows standard dll interface usable from the most popular application programs. Linux support consists of installation files and basic samples for programming from the user level via an open source kernel driver.

The USB-DIO-32 is available now, and the price starts at $119.00.

For more information, contact:

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San Diego, CA 92121
858-550-9559
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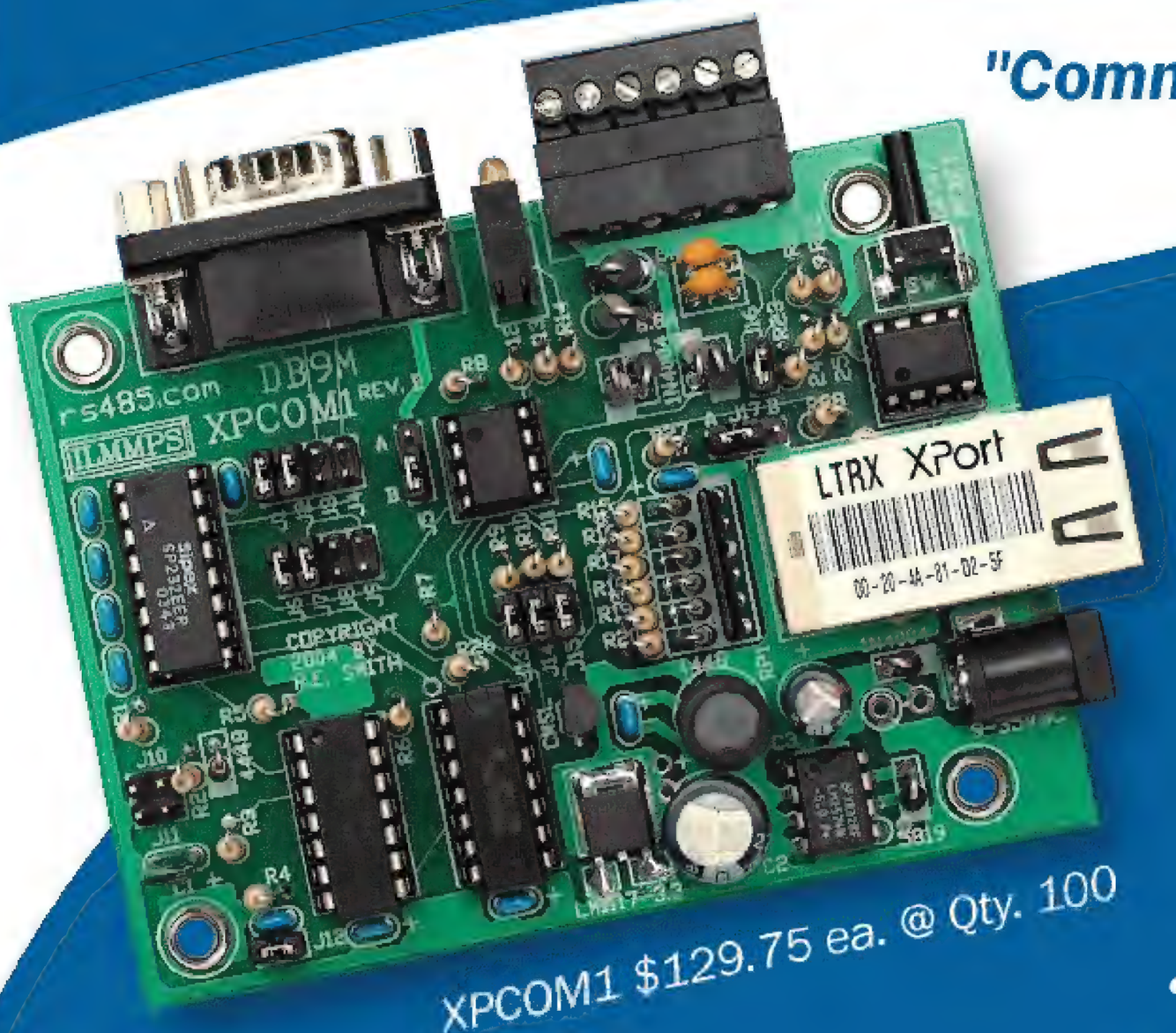

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by Dan Gravatt

PIC-based Motorcycle Gear Indicator

What Gear Are You In?

The Fuzzball Rating System

To find out the level of difficulty for each of these projects, turn to Fuzzball for the answers.

The scale is from 1-4, with four Fuzzballs being the more difficult or advanced projects. Just look for the Fuzzballs in the opening header.

You'll also find information included in each article on any special tools or skills you'll need to complete the project.

Let the soldering begin!

A while back, a friend of mine with a Suzuki Katana motorcycle sent me some plans he pulled off the Internet for circuits that would tell him what gear his motorcycle was in while he zipped down the highway. Since I'd helped him with some other electrical and electronic projects for his bike, he figured I could build one of these for him. I looked over the schematics he had found but wasn't too impressed — most were for "strip gauges" which lit a different LED for each gear, and none were very elegant. Rather than build one of these, I decided to start from scratch.

Background

It turns out that most motorcycles don't have any way of telling you what gear you are in while you are riding. The gears are shifted by lifting or pushing the gearshift lever with your left toe, and it's up to the rider to remember how many gears he or she has shifted through. The bike does know when it's in neutral because of a "neutral position switch" mounted on the transmission, and a single indicator light is usually provided for the rider. On my friend's Katana (and apparently on many other bikes), this neutral position switch consists of a metal wiper on the side of the transmission that steps back and forth over a set of electrical contacts as the gears are shifted. These contacts appeared to offer an easy way to determine which gear was in use at any given time.

Unfortunately, on my friend's bike, only a partial set of contacts was present in the position switch — neutral, first gear, and second gear. I confirmed that each contact was grounded when the transmission was shifted to that position, but without a full set of contacts, we were stuck. The Internet came to our rescue. He found plans (which were very elegant) to construct a fully functional position switch, and I got back to designing the indicator circuit.

Development

Between my friend's ideas for the new gear indicator and my own, I came up with a short list of design features: a digital display using blue LEDs and a weather-resistant enclosure as small as possible. I dusted off my

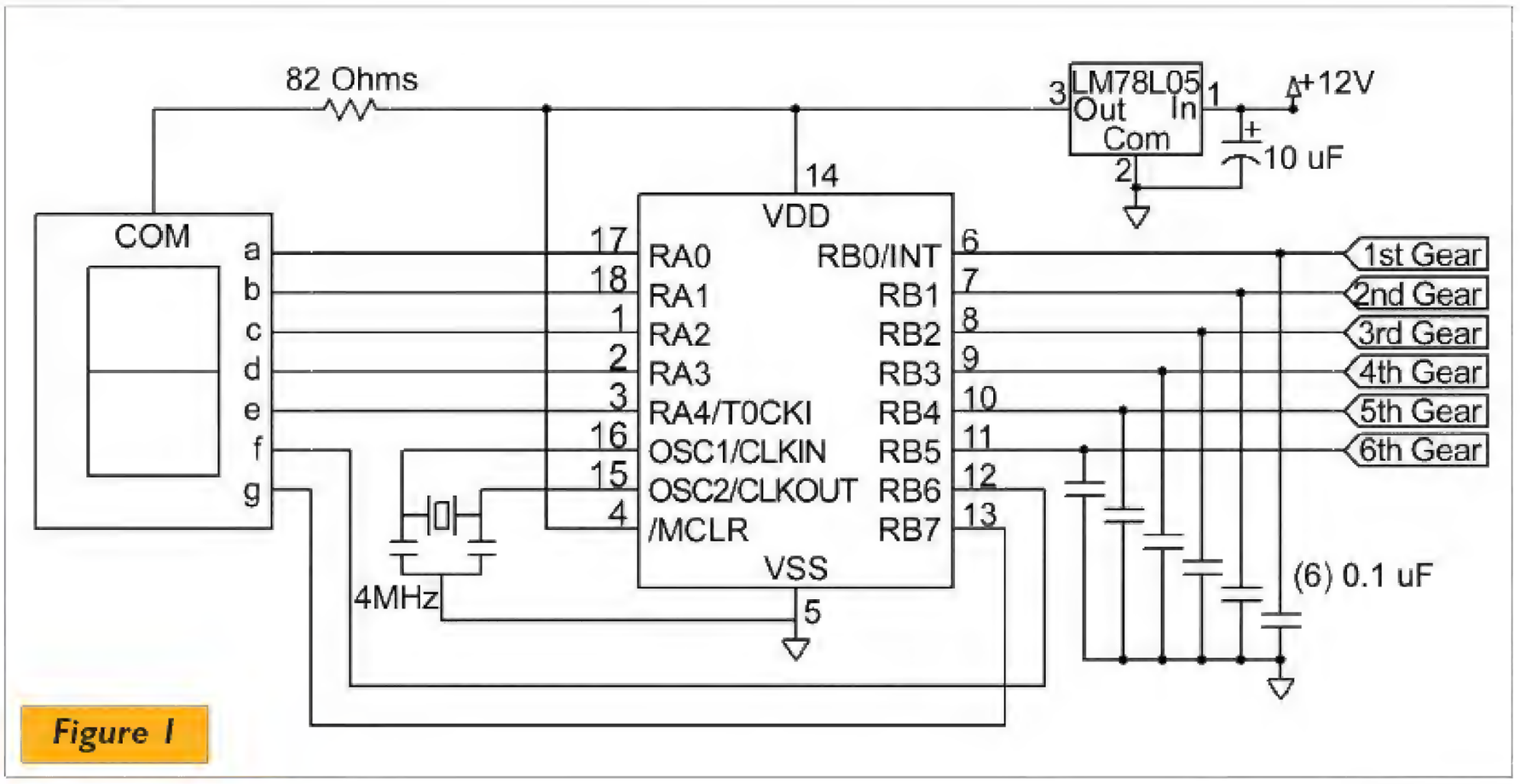

Figure 1

TTL databook and came up with a circuit using a 74LS148 8-to-3 priority encoder to read the position switch outputs and a 74LS47 display driver for a seven-segment LED display. It was digital, and it worked, but it wasn't all that small.

With some lucky catalog searching, though, I found a way to make it quite weather-resistant: translucent enclosures from Serpac which are pretty well color-matched to red, green, and blue LED displays. The display shines right through the case, so I didn't have to try to cut a neat rectangular hole and then seal it against water entry. I only needed to drill one small hole for the power and position switch wiring.

My friend used this design on his bike for a while and liked it, but it was really too big for the postage-stamp sized "dashboard" on his bike. I went back to the drawing board for a design that met all of our design criteria. I decided on using a low-end PIC microcontroller to reduce the parts count, and settled on a 16F84 because I found lots of information on how to program it. The schematic I came up with is in Figure 1.

All 13 of the PIC's I/O lines are used; six for reading the position switch outputs and seven to drive the LED display. The position switch outputs are routed to PortB pins RB0-RB5 to take advantage of the 16F84's internal weak pull-up resistors. Note that the circuit does not include an input for the neutral position, since the program assumes you are in neutral if none of the gear inputs are active. The program code is listed in Listing 1.

Construction

I'll admit it — building this circuit using through-hole components in the enclosure I used was a bit challenging due to space constraints. For a little more "elbow room," you may want to use a slightly larger enclosure than is specified in the Parts List (SCR6TL rather than SCR4TL). Either way, start by cutting a piece of pad-per-hole perfboard so that it fits tightly in the case, and drill a hole to clear the case's central mounting screw. Lay out the parts on the perfboard as shown in Figure 2, unless the design of your motorcycle has the gear position switch on the right side of the bike. If your bike is built this way, you may want to mirror-image this layout so the wiring harness exits the right end of the case. Solder everything in place, making sure you've programmed and tested the 16F84 microcontroller first!

I had some problems initially with the operation of this circuit on my friend's bike which I traced to electrical noise on the position switch wires. Adding bypass capacitors to these wires as close to the microcontroller as possible fixed the problem. Depending on the bike and the level of electrical noise, the suggested 0.1 uF value may or may not be sufficient, so use whatever value works for your bike. Surface-mount type capacitors may be needed to fit in the limited space available in the case.

Once the circuit assembly is finished, drill or grind a hole in one end of the case big enough to pass the power/position switch output cable through. Solder the wires from the cable to the circuit board (keep notes on which color wire corresponds to each connection), route the cable through the hole, and assemble the case. If your

Listing 1

```
POKE 134, 63            'MAKES RB0-RB5 INPUTS, RB6-RB7 OUTPUTS
POKE 133, 0             'MAKES RA0-RA4 INPUTS
POKE 129, 127           'TURNS ON INTERNAL PULL-UPS ON PORTB

START:
PEEK 6, B0              'READS PORTB PIN STATES INTO MEMORY B0
PAUSE 500               'DECREASES DITHER WHEN SHIFTING GEARS

IF BIT0=0 THEN ONE      'CHECKS IF 1ST GEAR IS ENGAGED
IF BIT1=0 THEN TWO      'CHECKS IF 2ND GEAR IS ENGAGED
IF BIT2=0 THEN THREE    'CHECKS IF 3RD GEAR IS ENGAGED
IF BIT3=0 THEN FOUR     'CHECKS IF 4TH GEAR IS ENGAGED
IF BIT4=0 THEN FIVE     'CHECKS IF 5TH GEAR IS ENGAGED
IF BIT5=0 THEN SIX      'CHECKS IF 6TH GEAR IS ENGAGED
GOTO NEUTRAL            'IF NO GEARS ARE ENGAGED

ONE:
POKE 5, 25              'RA4-RA0 = 11001
POKE 6, 192             'RB7-RB6 = 11 AND LSBs IGNORED
GOTO START

TWO:
POKE 5, 4               'RA4-RA0 = 00100
POKE 6, 64              'RB7-RB6 = 01 AND LSBs IGNORED
GOTO START

THREE:
POKE 5, 16              'RA4-RA0 = 10000
POKE 6, 64              'RB7-RB6 = 01 AND LSBs IGNORED
GOTO START

FOUR:
POKE 5, 25              'RA4-RA0 = 11001
POKE 6, 0               'RB7-RB6 = 00 AND LSBs IGNORED
GOTO START

FIVE:
POKE 5, 18              'RA4-RA0 = 10010
POKE 6, 0               'RB7-RB6 = 00 AND LSBs IGNORED
GOTO START

SIX:
POKE 5, 2               'RA4-RA0 = 00010
POKE 6, 0               'RB7-RB6 = 00 AND LSBs IGNORED
GOTO START

NEUTRAL:
POKE 5, 11              'RA4-RA0 = 01011
POKE 6, 64              'RB7-RB6 = 01 AND LSBs IGNORED
GOTO START
```

Figure 2

Parts List

	Digi-Key Part No.
16F84 microcontroller	PIC16F84A-04/P-ND
Translucent blue case	SCR4TL-ND
5-volt regulator	LM78L05ACZNS-ND
10 uF bypass capacitor	P975-ND
82-ohm resistor	82QBK-ND
4-MHz resonator	X902-ND
Blue LED display	160-1517-5-ND

Miscellaneous: Input bypass capacitors, perfboard, eight-conductor cable.

bike only has five gears instead of six, omit the sixth-gear wire from the circuit.

Installation

First, a few words of caution. Installing this device on your motorcycle may void your warranty and/or create unsafe riding conditions if the device is not properly installed and secured! Every motorcycle is different, and it is your responsibility to install this device safely and properly on your particular bike.

Also keep in mind the circuit is somewhat sensitive to static electricity, so make sure the bike is turned off and observe handling procedures for static-sensitive devices.

First, locate and examine the gear position switch on your bike. If it has a full set of contacts representing all of the gears, great. If not, you will need to either modify the existing switch to add the missing contacts (plans for doing this are available on the Internet for some bikes) or procure a complete switch from a dealer or other source. Once you have a complete position switch, connect the position switch wires from the circuit to the corresponding contacts on the switch. Do not disconnect any existing wiring to these switch contacts! Then connect the power and ground wires from the circuit to the switched power bus in the bike (i.e., energized when the bike is running). Secure the display case and the wiring away from hot and/or moving parts, making sure that they cannot come loose during riding and do not interfere with steering the bike or operating any of its controls.

Operation

When the motorcycle is first turned on with the transmission in neutral, the display will show a lower case "n." As the transmission is shifted, the display will show the number of the current gear. A half-second delay is built into the program to minimize any "dither" when shifting gears, although you may see an "n" displayed during shifting. If the display is erratic when riding but not when the bike is first started, you may have excessive electrical noise on the position switch wires which requires additional bypass capacitance. **NV**

About the Author

Dan Gravatt is a licensed geologist with the State of Kansas. He can be reached at dgravatt@juno.com

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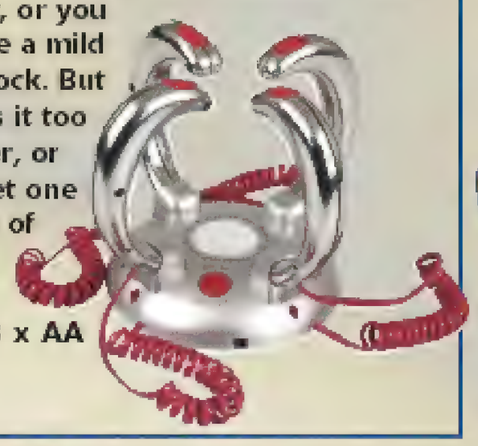

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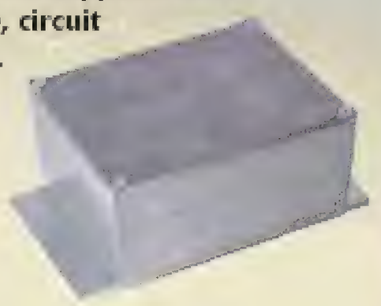

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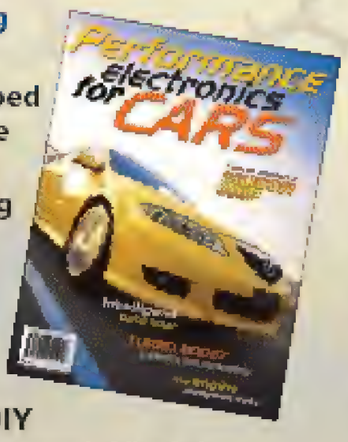

Australia's leading electronics magazine, Silicon Chip, has developed a range of projects for performance cars. There are 16 projects in total, ranging from devices for remapping fuel curves, to nitrous controllers, and more! The book includes all instructions, components lists, colour pictures, and circuit layouts. There are also chapters on engine management, advanced systems, DIY modifications, and more. Over 150 pages! All of the projects described are available in kit form, exclusively from Jaycar. Check out our website for all the details.

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Circle #31 on the Reader Service Card.

by Alonzo Trueland

Battery Analyzer for RC Power

To "Charge It" or Not to "Charge It" is the Question

Knowing the discharge characteristics of the battery in your portable drill may not be very important, but having this kind of information is vital if you want to be competitive in any type of electric RC event. I was rudely reminded of the need for such a device when my electric boat stopped in the middle of the lake! It was only two minutes into its run that should have lasted six minutes when it gave-up. I suspected the battery was bad, but this should not be the way to find out! If I was able to monitor the batteries performance during its usable life span, a problem may have been detected. If you know what your battery is capable of, it is easier to develop a winning strategy.

This battery analyzer project is designed to test the "health" of battery packs used in radio-controlled vehicles to drive their motors. An effective way to test the health of a battery pack is to place a normal operating load on a fully charged pack, and then record the voltage levels while it is discharging through a test load. The information produced from the recorded data will create a graphical "discharge curve" that can be used to examine its performance level and determine the health of the battery under test.

The battery analyzer covered here can be divided into three main parts: the test-load, interface board, and computer program. The test-load provides a controlled discharge current for the battery under test. The interface board measures the battery voltage during testing and transmits the data to the computer. The computer program will display the test information in a graphical form and provide the means to save the data for later review. Figure 1 shows the analyzer on the bench and ready to dish-out some battery pack punishment!

Skills Needed

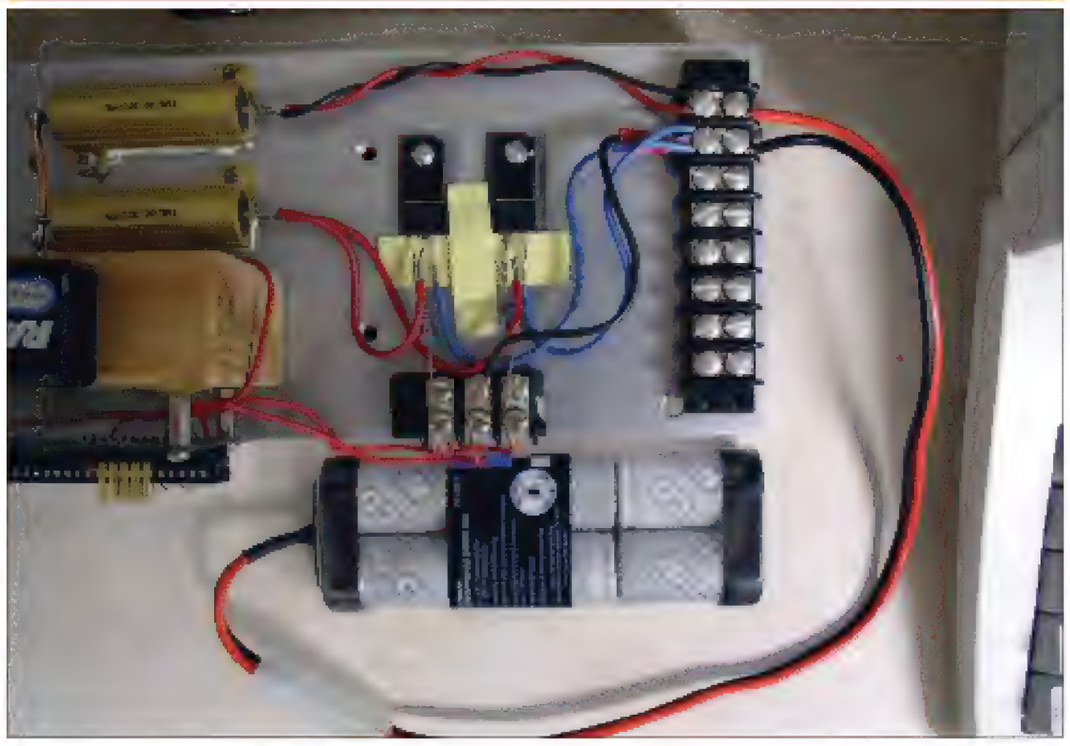
The project is relatively simple to assemble, but the combination of software and hardware could be difficult for a novice to troubleshoot. The high-current nature of this project requires sound assembly techniques. Bad connections, excessive wire, insufficient heat dissipation, and poor assembly are some things that could cause frustration or possibly injury. An intermediate level of experience with the outlined software and their associated tools will be needed if the builder wishes to modify the programs.

The Test-Load

Figure 2 shows how the battery connects to the test-load using the standard connector that comes with most pre-assembled battery packs. The load is a simple voltage divider made with two 0.3 ohm 50 watt power resistors mounted to a large heatsink. The total 0.6 ohm load will provide a 12 amp test current for a 7.2 volt six-cell RC battery pack. The voltage is measured at the center of the divider giving the tester a theoretical maximum battery input voltage of 10 volts. At 10 volts, the divider will limit the input to the data collector board to five volts. The practical test voltage should be limited to 7.2-8.4 volts

Figure 1. Analyzer on the bench.

Figure 2. Battery connected to the test load.



because the wattage levels could be exceeded.

RC packs are assembled using multiple single battery cells that nominally produce 1.2 volts at full charge. The number of cells in a pack depends on the application. A typical RC car battery will contain six cells and produce 7.2 volts, while a model boat application may have 12 cells supplying 14.4 volts of RC pleasure. Hobbyists can easily design power packs to meet any power requirement by simply assembling the proper number and type of cells to satisfy the need. This test-load is only designed for a 7.2 volt six-cell RC pack. At 7.2 volts, there will be a 12 amp current producing about 86 watts of wasted energy. The two 50 watt resistors are not rated to handle much more power than this. The test-load will have to be carefully designed to handle the power being dissipated if higher current levels are to be analyzed. If higher voltage packs are used, the test-load will require design changes that limit the maximum voltage to the data board to five volts. Adding resistors in series will divide the test voltage into safe levels for the interface board to process. The PC software will also need to be changed to support a different voltage division other than the current design of one-half.

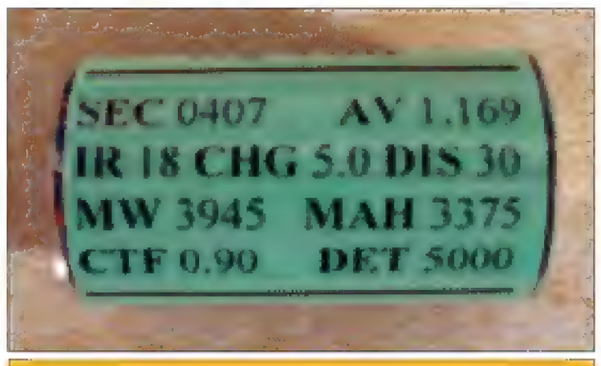


Figure 3. Label with battery cell specifications.

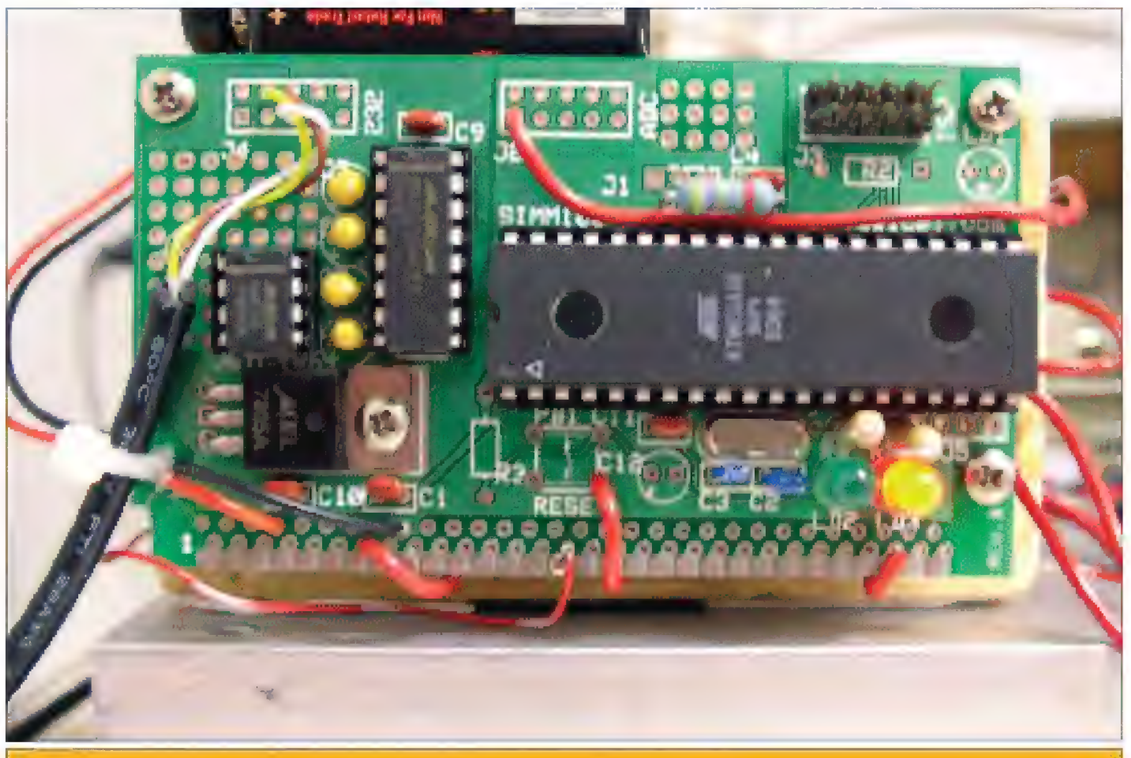


Figure 4. Interface board.

The current output of batteries designed for RC applications is incredible! A high performance electric boat may draw between 40-50 amps during a race, but battery life is reduced. A lower, 30 amp level is what high-performance battery manufacturers recommend as the norm for battery longevity and has become the standard performance test-spec when comparing batteries from different makers.

Batteries are rated in how much current can be supplied for one hour or milliamp hours (mAh). A typical 1,000 mAh RC battery can supply one ampere of current for one hour, or 10 amperes of current for six minutes. High capacity battery cells in the 3,000 mAh range will usually have their specifications advertised in the form of a label placed on each cell (Figure 3). The discharge-time, capacity, internal resistance, average voltage, and other info that appear on the label are typically done at a 30 amp discharge rate. These statistics are important factors when choosing a race-winning power source.

It could be argued that a 12 amp test-load is not enough to fully exercise a battery pack used for racing. It is possible that a battery will test fine at a 12 amp rate, but fail when tested using a 30 amp rate. I chose a 12 amp rate so that a wider range of battery capacities can safely be tested. A 1,500 mAh sport battery will not last long if subjected to several high-current test sessions.

There is always an explosion hazard when charging and discharging batteries that is reduced when operating at lower power levels. High current problems are still easily detected if a history is kept about the battery. A new battery should be tested and the results be kept as a baseline for future tests. Test data done during the life cycle of the battery can be compared to the baseline test report. Any significant change in performance from the baseline is a good indicator that the battery will most likely fail during racing conditions.

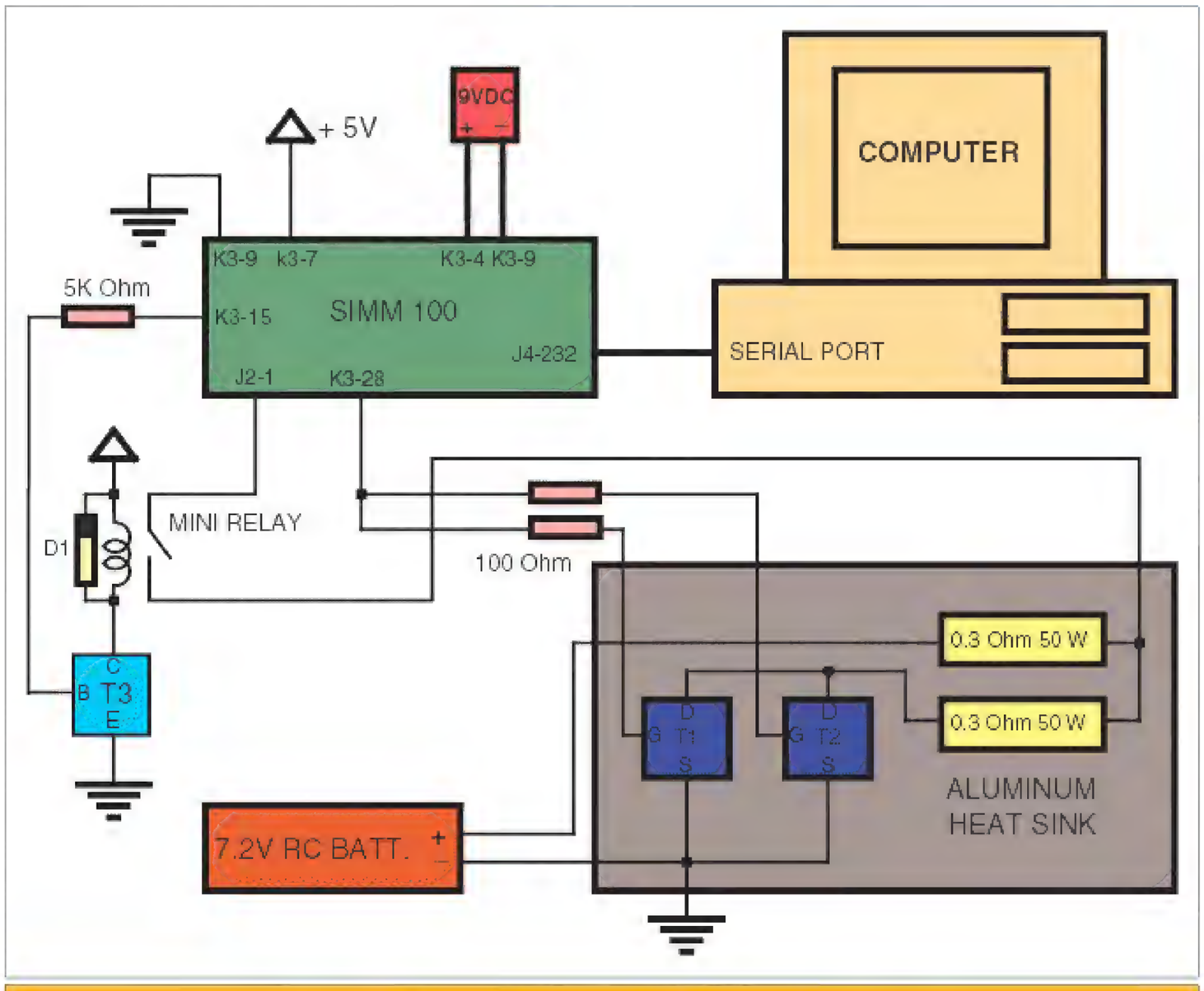


Figure 5. Connection diagram.

The Interface Board

The interface board (Figure 4) is a SIMM100 PCB from Lawicel that is fitted with an ATmega16 AVR microcontroller from Atmel. I received my SIMM100 PCB from MCS Electronics (**www.mcselec.com**) and populated it with components purchased from Digi-Key at **www.digikey.com** A manual complete with schematic and parts list for the SIMM100 can be found at **www.lawicel.com**

The responsibilities of the interface board are: measure the divided battery voltage created by the test-load, then transmit measured data to the serial port of the computer, and also control the connection of the load and ADC to the battery. Figure 5 shows a connection diagram of the analyzer. FETs T1, T2, and T3 are controlled by the interface board to connect/disconnect the load and ADC (analog-to-digital converter) input from the battery under test. The interface board will connect the load by turning ON T1/T2 and the ADC using T3 after it receives a "Go" control word from the PC to start testing.

When the test is done, the PC will send a control word to disconnect the ADC then the load by turning OFF the transistors. It is important to automatically disconnect the load because batteries can be damaged if discharged beyond their cut-off voltage (more on this later). During testing, measured voltage is fed into the microcontroller's 10-bit ADC, processed, and then sent to the computer via a RS232 level-shifting chip. The SIMM100 has a ground plane that greatly reduces interference and promotes stable analog-to-digital conversions making this board a perfect control solution.

Bascom-AVR is a "Basic" language compiler from MCS Electronics that was used to program the interface board. MCS Electronics provides a generous demo that is only limited by its 2K byte program size. The program for this project is fully supported by the demo version and will easily fit in the size limit. You can download your own demo at **www.mcselec.com** I used the STK500 development board from Atmel to program the chip, but in-circuit programming is supported by the SIMM100 when done with a compatible programmer.

Listing 1 shows the small amount of Basic code that is needed to support the project requirements. The program only fills six percent of the controller's memory, making the ATmega16 a little bit of an over-kill for this application.

The simplicity of the interface program makes it a little boring, but is an important part of the system. The program starts with its typical initializations, with the most important being the activation of the ADC. The "Config Adc" statement makes this process easy. Once the ADC is started with the "Start Adc" command, you only have to call the "Getadc()" routine to snatch a measurement from the converter.

After everything has been initialized, the program waits for the PC to send a control word via the serial connection to start the battery testing. The program will loop using the "loop until good=1" statement until it is satisfied. The program will fall through when the interface board receives a control word from the PC. The "Relay_con" routine will execute when a character is received in the serial buffer. The "input" statement is used to capture the control word and store it in the variable "Relcon." The control word "Go1" will start the process by connecting the ADC to the load and turning ON the FETs with a sample rate of five seconds, while "Go2" will use a sample rate of 10 seconds.

If a "Stop" control word is received, the program will do just that by disconnecting the ADC and turning OFF the FETs. The program will then just wait for something to do. After getting the go-ahead from the PC, the program will continue to get an ADC value and send it the computer at the selected sample time until a "Stop" command is received. Two LEDs on the board give a quick visual of what is going on; RED stopped, GREEN plotting.

The automated connection of the ADC is needed to prevent device damage by excessive V-input. The ADC is connected to the load via a mini relay AFTER the power resistors begin dividing the voltage into a safe level. The ADC must also be disconnected BEFORE the load circuit is open to prevent device damage. Even though the routine is simple, it is a great building block for more complex control applications.

The Computer Program

The computer program was written using Microsoft's Visual Basic 6.0 programming environment for Windows. A tutorial on VB is way beyond the scope of this article, but the easy-to-understand syntax usually provides enough information for even non-programmers to gain a good understanding of what is going on. The entire program is too lengthy to publish, but the complete program listing can be found at the *Nuts & Volts* website (**www.nutsvolts.com**) in their FTP library.

Listing 2 is really the heart of the program and deserves recognition because most of the process-

Listing 1. Interface board program.

```
$crystal = 10000000

Dim W As Word
Dim Relcon As String * 5
Dim Deltm As Byte
Dim Good As Bit

Good = 0                    'loop control

Config Pinc.0 = Output      'green LED
Config Pinc.1 = Output      'red LED
Config Pinc.5 = Output      'FET control
Config Pinb.0 = Output      'ADC control
Portb.0 = 0                 'ADC disconnect
Portc.0 = 1                 'green LED off
Portc.1 = 0                 'red LED on
Portc.5 = 0                 'load off

On Urxc Relay_con           ' interrupt routine set
Enable Urxc
Enable Interrupts

Config Adc = Single , Prescaler = Auto , Reference = Avcc
Start Adc

Redo:
Do
Loop Until Good = 1         'wait for a control word


Do
W = Getadc(0)
Print W;
If Deltm = 5 Then
   Wait 5
End If
If Deltm = 10 Then
   Wait 10
End If
Loop Until Good = 0         'send data until stop is sent

Goto Redo

End

Relay_con:
Input Relcon Noecho                 'get control word
   If Relcon = "Go1" Then           'use 5sec delay
      Deltm = 5
      Portc.5 = 1                   'Connect load
      Waitms 500
      Portb.0 = 1                   'connect ADC
      Waitms 500                    'wait for relay to close
      Portc.0 = 0                   'toggle LEDs
      Portc.1 = 1
      Good = 1                      'fall through do-nothing loop
   End If
   If Relcon = "Go2" Then
      Deltm = 10                    'use 10sec delay
      Portc.5 = 1
      Waitms 500
      Portb.0 = 1
      Waitms 500
      Portc.0 = 0
      Portc.1 = 1
      Good = 1
   End If
   If Relcon = "Stop" Then          'stop analyzing
      Portb.0 = 0                   'disconnect ADC
      Waitms 500                    'wait for relay to open
      Portc.5 = 0                   'disconnect load
      Portc.0 = 1
      Portc.1 = 0
      Good = 0                      'return to loop
   End If
Return
```

ing time is spent here during its execution. Listing 2 is the routine that is called when a character is received into the serial buffer of the computer from the interface board. After the computer tells the interface board to begin analyzing, the interface board starts to send data samples to the computer. Every data sample received is handled by the routine in Listing 2.

Listing 2 is an event procedure that is associated with a control called "CommX1." CommX1 provides the means for your VB program to use the serial port of the computer for communication. CommX1 is a third party tool that does not come with VB and must be added to the programming environment before it can be used. VB comes with its own Comm Control, but it is only available with the more expensive versions of the program. The VB "learning addition" is what most beginners start out with, but does not have this needed tool. One of the nice features of VB though, is that it's designed to support programming tools from other vendors. Lucky for us CommX1 can be downloaded for free from MCS Electronics so that even the beginner versions of VB can be used to develop some respectable control applications.

After the computer starts the analyzing process by sending the proper control word to the interface board, it waits until a data value is received at the serial port and then processes it. Note.1 of Listing 2 is where the serial data is retrieved and stored at variable "volt." Between note.1 and note.2, the ASCII data from the interface board must be converted into a numeric value so a voltage level can be calculated from the ADC value. Once a voltage value is obtained, it is displayed on the computer monitor.

Between note.2 and note.3, the voltage data is used to calculate where to plot the voltage measurement on the graph. The program uses the default VB unit of screen measurement called "twips." Each vertical volt designation is equal to 500 twips of resolution. The discharge graph time resolution is in the horizontal direction or X plot position, while the voltage measurement is in the vertical direction or Y plot position. If the voltage measured is five volts, the Y plot position will be 2,500 twips up from the zero level.

Between note.4 and note.5, the program will set the first X plot point at the zero time designation and the Y plot point will depend on the voltage value.

Between note.5 and note.6 is where the graph gets drawn by calculating a Y plot point (voltage) from each measurement, moving the X plot point (time) a defined number of twips to the right, and then connecting the plot points using the line method. This will continue until it reaches the end of the graph, is stopped by the user, or falls below the cut-off voltage. This section of code is also responsible for filling a table with voltage values that can be printed for record keeping (more on this later).

Code between note.6 and note.7 is executed when plotting reaches the end of the graph or the battery voltage falls below the cut-off level. The program will then halt testing by sending the "stop" command to the interface board and closing the serial connection.

Listing 2. VB Serial Communications sub-routine.

```
Private Sub CommX1_OnReceive(ByVal DATA As String)
Dim volt As Integer
Dim volt2 As Single
Dim volt3 As String
Dim volt4 As Single
Dim volt5 As Integer
Static x As Integer
volt = Val(DATA)                                        '**NOTE 1**
volt2 = (volt * 0.004888) * (2)
volt3 = Str(volt2)
volt3 = Left$(volt3, 5)
Label28.Caption = volt3
volt4 = Val(volt3)                                      '**NOTE 2**
volt5 = volt4 / 0.01  'convert to twips
volt5 = volt5 * 5     '1volt=500 twips                  '**NOTE 3**
If check = 0 Then                                       '**NOTE 4**
    Form1.CurrentX = 1000
    Form1.CurrentY = 6000 - volt5
    check = 1
Else                                                    '**NOTE 5**
     vertical = 6000 - volt5
     Line -(Form1.CurrentX + 50, vertical)
     MDIForm1.frm.grdTable.Row = Tr
     MDIForm1.frm.grdTable.Col = Tc
     MDIForm1.frm.grdTable.Text = volt3
     Tr = Tr + 1
     If Tr = 13 Then
        Tc = Tc + 1
        Tr = 1
     End If
     x = x + 1
     If x = 120 Then                                    '**NOTE 6**
        x = 0
        CommX1.SEND "Stop" + Chr(13)
        CommX1.Close
        Command2.Enabled = False
        Command3.Enabled = False
        MDIForm1.mnuPrint.Enabled = True
        Form1.Caption = Format$(Now, "mmmm dd yyyy h:mm a/p")
        MDIForm1.frm.Caption = Format$(Now, "mmmm dd yyyy h:mm a/p")
        MDIForm1.frm.grdTable.Enabled = False
        Label36.Caption = "STOPPED"
        Label36.ForeColor = &HFF&
        Exit Sub
     End If
End If
If (volt4 < Cutoff) Or (volt4 = Cutoff) Then            '** NOTE 7**
    Call Command3_Click
End If
End Sub
```

Using the Analyzer

Using the analyzer is pretty simple. You first load the computer program while mak-

Figure 6. Splash screen when the program is first loaded.

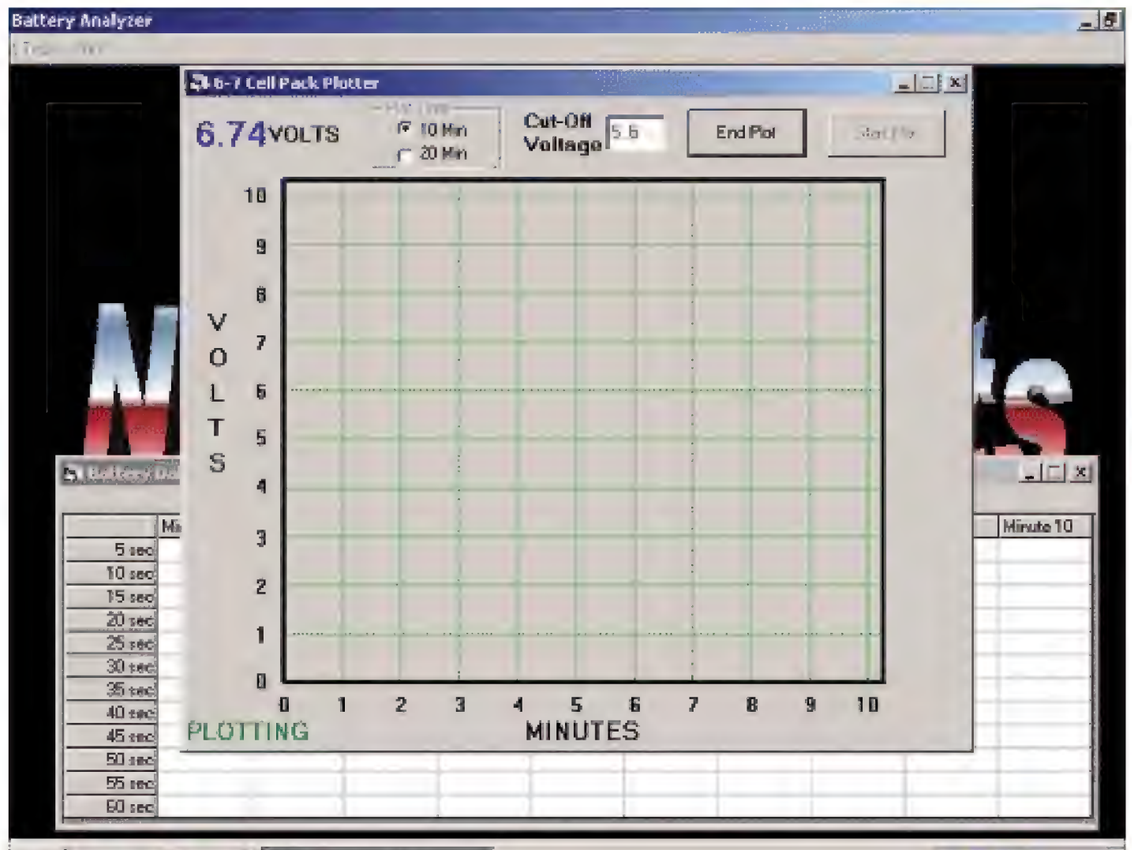


Figure 7. The program is ready.

ing sure that no other program is using Comm1. Comm1 should be available on most computers and already assigned to the serial port. The standard serial port has somewhat been abandoned for the newer, high speed connections like USB and FIRE WIRE, making the easy-to-use standard port an excellent control solution. If a different Comm resource is needed, the program can be modified to use a different Comm selection.

After the computer has been set up, the interface board needs to have power applied. I use a simple nine-volt battery to power the board, but any 9-12 volt DC source will work. Once the board has power, the RC battery pack can be connected to the test-load.

Figure 6 shows the splash screen that is displayed when you first load the program. You must select either a six-cell or single-cell test from the "plot type" menu. An option to test a single cell is included, but isn't explored in this article (see special notes). After selecting the six-cell test, Figure 7 shows the program ready for business. You must then select the test time using the option buttons. There are a total of 120 samples taken with a sample rate of five seconds for 10 minutes, or a sample rate of 10 seconds for the 20-minute run.

Finally, the cut-off voltage must be entered before testing can happen. The cut-off voltage is the minimum voltage level that a battery can safely be discharged without damage. A typical cut-off voltage for a single-cell is 0.9 volts, making the cut-off for a six-cell pack 5.4 volts (0.9 x 6). The load is disconnected from the battery when the voltage meets the entered cut-off value. It is important to know the proper cut-off value of the pack under test and enter a safe value slightly above the manufacturer's spec. A value of 5.6 is a good value to work with if you want to be safe.

Once the time and cut-off values are entered, the "start plot" button can be clicked to begin the testing. The load will be connected and the interface board will start sending data. During testing, a graph is drawn showing the voltage trend while the voltage readout is updated with every new sample value. Each sample is placed in a table during testing, and can be viewed in real time. The test will

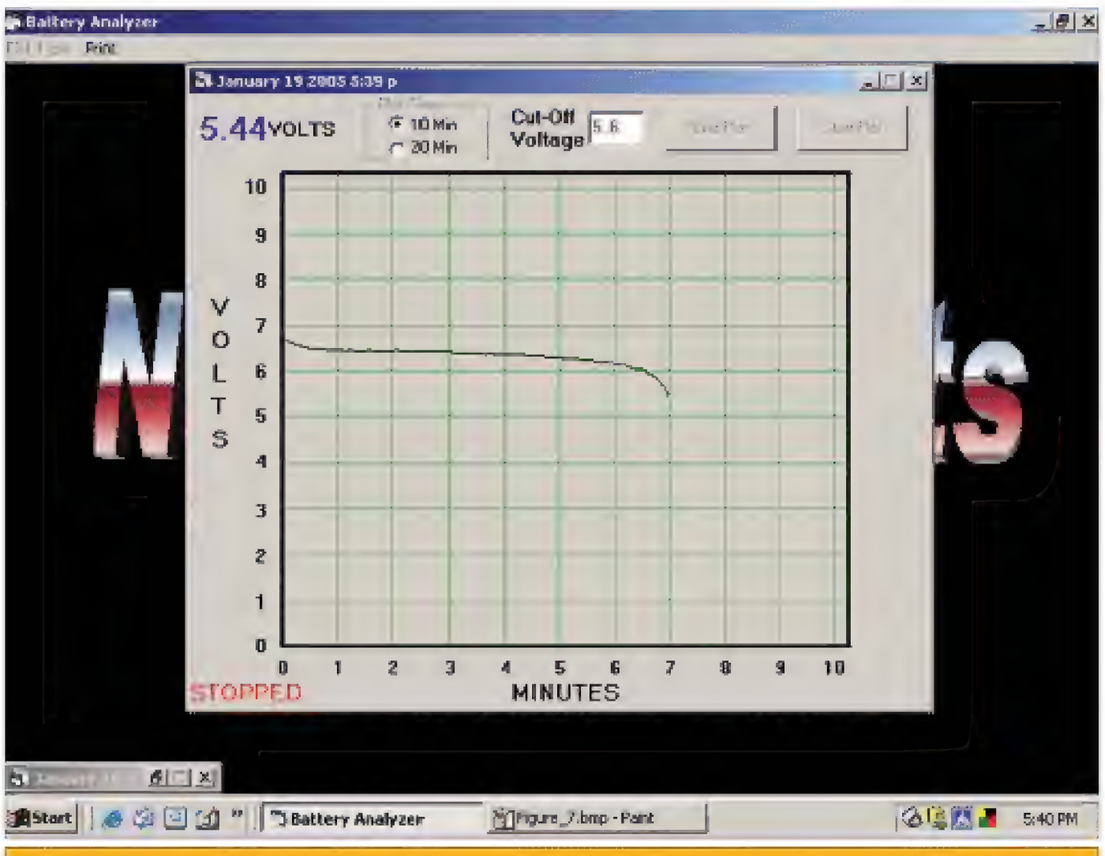


Figure 8. Discharge curve of a battery pack.

stop if the cut-off voltage is met or the time has expired. You can also stop the test by clicking on the "End Plot" button.

Figure 8 shows a finished test-graph or now called a "discharge curve" of one of my battery packs. Figure 9 shows the data table that was created. You can print the data table by selecting "print" from the menu. In an effort to keep the program simple, I did not include a menu option to print or store the discharge-graph. You can store and print the graph by copying it to the clipboard using the "print screen" key on the keyboard. You can now "paste" the captured graph into MS Paint where it can be printed and saved for later review. A new test session can't start until the graph-form has been closed, so make sure you copy the data and graph to a file if you want to save the results.

Special Notes

If you wish to modify the VB code, there are a couple of issues that need to be addressed. The CommX1 control will need to be added to the component section of the VB environment before you attempt to run the program during design-time. An error will be produced if it does not find the CommX1 control. If you are fortunate enough to have a version of VB that includes the MScomm control and you would rather use that control, the code will have to be modified by removing the CommX1 control code and adding support for the MScomm control.

A second control issue is with the data table that holds the voltage samples. This is a "flex grid" control that is not found on basic editions of the VB environment. You will get an error at design-time if the version you are using does not have this control. If you want to modify the code and don't have this control, there are other methods to print data during testing. You can simply remove all references to the flex control and add a simple routine that prints the data to a form in a formatted table that can be saved using the same print screen method. There are several solutions that are well within the capability of the program.

To make your modified creation a stand-alone" .EXE" program, a version that typically costs more than most hobbyists can afford will be required. If access to a version with this support is unavailable, you will just have to run your code from within the VB programming environment.

A good reason for modification/enhancement would be to change the time increments or voltage increments. A better but more complicated program would include a control to allow dynamic changes to the graph for different measurement ranges and resolutions. The program is best viewed at 800*600, but will still work well at finer settings. The feature-rich possibilities are endless and only limited by the imagination.

The single-cell option uses a voltage scale from 0-2 and does not require a voltage divider; 1.2 volts is well below the five-volt ADC limit,

Parts List

Materials

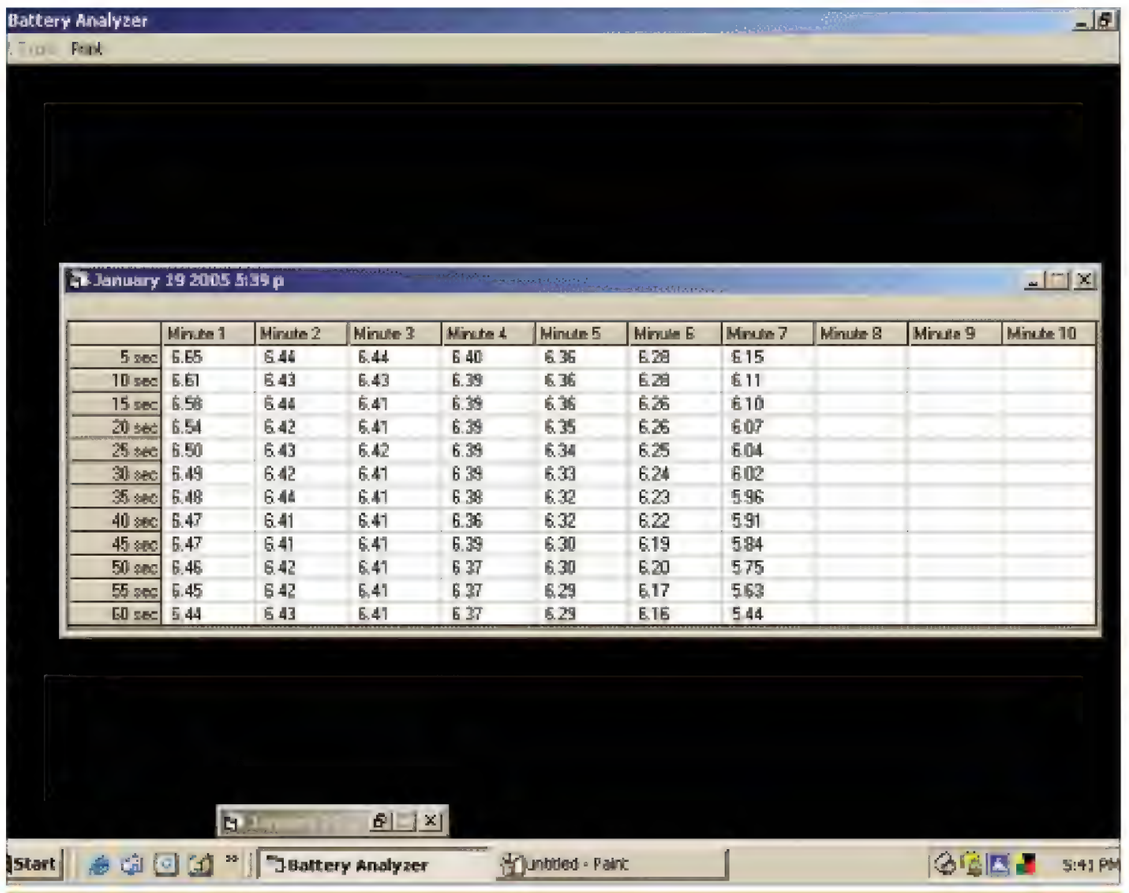
1. SIMM100 PCB or similar AVR circuit.
2. Components for interface board: Mega16, Max232, Max701, and support components as described in the Simm100 manual.
3. 2 — IRL3103 FET (T1,T2). *Logic level with a low ON resistance.
4. 1 — 2N222 NPN transistor (T3).
5. 2 — 0.3 ohm power resistors (aluminum housing).
6. 2 — 100 ohm resistors.
7. 1 — 5K ohm resistor.
8. 1 — Five-volt DC mini relay.
9. 1 — 1N4004 diode.
10. Suitable heatsink for power devices.
11. One battery connector that mates to the style used on the batteries being tested.
12. 14-gauge wire for connecting resistors and FETs to the test battery.

Tools

1. Method to program microcontroller: STK500, AVR-ISP, Kanda200, etc.
2. Computer running Windows™ operating environment.
3. Bascom-AVR software (if you want to modify the program).
4. Visual Basic programming environment (if you want to modify the program); see "special notes."
5. Normal project things: hand-tools, soldering iron, goggles, voltmeter, etc.
6. Fire extinguisher (you can't be too safe!).
7. Knowledge needed to implement project requirements (priceless).

eliminating the need to adjust the test voltage to a safe level for the ADC input. A different test-load using paralleled power resistors designed for the desired load current would be needed to support this option. The program does not double the measurement to obtain a true voltage for one cell like it does for six cells, so a voltage divider will yield incorrect data.

It is assumed that anyone attempting to build this type of project has the knowledge needed to safely implement the information outlined in this article. When working with high performance batteries that are capable of delivering high currents, several hazards exist such as explosion, burns, fire, equipment damage, etc. I never leave a pack that is being tested unattended. I frequently touch the pack to check if it is getting too hot. The danger is relatively low — especially if you monitor the pack's temperature — but it is something to be mindful of.



	Minute 1	Minute 2	Minute 3	Minute 4	Minute 5	Minute 6	Minute 7	Minute 8	Minute 9	Minute 10
5 sec	6.65	6.44	6.44	6.40	6.36	6.28	6.15			
10 sec	6.61	6.43	6.43	6.39	6.36	6.28	6.11			
15 sec	6.58	6.44	6.41	6.39	6.36	6.26	6.10			
20 sec	6.54	6.42	6.41	6.39	6.35	6.26	6.07			
25 sec	6.50	6.43	6.42	6.39	6.34	6.25	6.04			
30 sec	6.49	6.42	6.41	6.39	6.33	6.24	6.02			
35 sec	6.48	6.44	6.41	6.38	6.32	6.23	5.96			
40 sec	6.47	6.41	6.41	6.36	6.32	6.22	5.91			
45 sec	6.47	6.41	6.41	6.39	6.30	6.19	5.84			
50 sec	6.46	6.42	6.41	6.37	6.30	6.20	5.75			
55 sec	6.45	6.42	6.41	6.37	6.29	6.17	5.63			
60 sec	6.44	6.43	6.41	6.37	6.29	6.16	5.44			

Figure 9. Data table.

Final Thoughts

This project can be easily modified to provide a solution for many different types of control applications. I wish I had the time to explore all the great ideas that popped into my head during the development of the project. At a minimum, I would like to expand the system to eight channels with temperature monitoring capabilities. Having multiple channels would allow several single-cell tests to happen at the same time. Battery packs can be assembled using cells that have similar discharge-curves making what is called in the battery industry "matched cells." It is fun seeing my old and destined-to-be-recycled computer doing some "real work" outside its box. A lot of processing power is not necessary, so don't throw away those ancient computers. The outdated hardware can still earn its keep by making your life easier through automation. NV

About the Author

I currently work for an area hospital as a PBX administrator. My experience with computer automation comes from several years of working for an electronics assembly manufacturer doing test-fixture design. Employment trends forced me from what I enjoy doing most, but I still find time to satisfy the urge to control something. I can be reached at trueland13@aol.com

Vendor List

Digi-Key
Components, AVR programmers, parts, etc.
www.digikey.com

Msc-Electronics
Bascom software, CommX1 control, microcontroller boards
www.mcselec.com

Dontronics
SimmStick stuff, tons of micro-related tools and components
www.dontronics.com

Lawicel
Microcontroller solutions
www.lawicel.com

Tower Hobbies
All things RC — batteries, connectors, chargers, etc.
www.towerhobbies.com

Atmel
AVR microcontrollers
www.atmel.com

by Michael Simpson

The Ultimate Utility Meter

Part 1 — The Basic Components

In December 2001, I wrote an article in *Nuts & Volts* called the "Digital Utility Meter." It was a great success and many readers built the meter. I think the reason it turned out so well was the fact that I used the meter to aid in many of my own projects.

Several months ago, I started a project where I needed to interface a microcontroller to a PC keyboard, and I was having problems getting it to work with several types of keyboards. My scope was no help. What I needed was a multi-channel logic analyzer, so I put my current project on hold and decided to build one.

After several attempts, I came up with the technique of capturing the logic data and sending the information to a PC, where a special program (shown in Figure 2) would display the results.

After adding a few features and options to the meter, I solved my original problem and found myself using the analyzer quite a bit. It won't compete with a $2,000.00 logic analyzer, but it has solved most of the problems I have had while trying to interface my microcontrollers to various chips and sensors. Best of all, it only cost me about $50.00 and provided me with a tool that I could expand on.

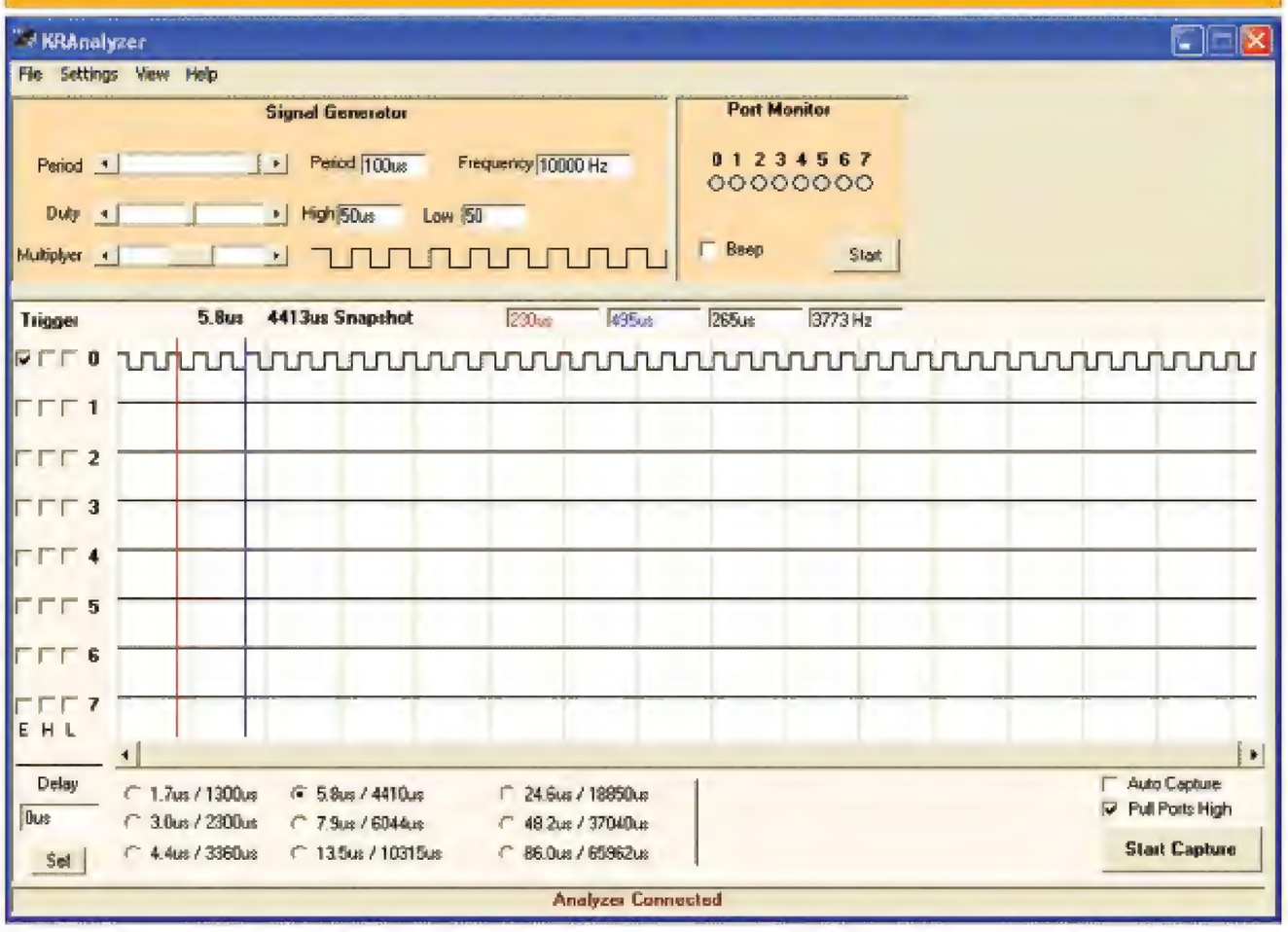
One downside to a PC-based analyzer is that you must use a PC. While this is okay for some, I constantly find myself needing the PC for other aspects of the project. After thinking a bit, I decided that I could build a small interface that could replace the PC. I could use a graphic LCD and a second microcontroller. After much experimenting, I came up with a nice little stand-alone graphic analyzer. Later, I added a signal generator and an eight-channel logic probe.

I used the analyzer for a few months and realized I could add two three-position DPDT switches and gain access to each of the microcontrollers independently. With the flip of a switch, I could connect the LCD controller directly to my PC, and this feature gave me a serial graphic LCD.

I could also program either microcontroller in place at the flip of a switch. This allowed me to use the Ultimate Utility Meter (UUM) as a bench test for other projects. For example, I was working on a special digital thermostat for my house and could not detach the thermostat from the wall and take it into my lab for any length of time. In the middle of winter, the family starts to complain once the house temperature drops below 60 degrees F. I found myself running back and forth, as I tested and debugged the thermostat. After about the 20th trip, I decided to replicate my thermostat project using the UUM. With very little effort, I created a test bed for my thermostat project.

Figure 1. The completed project.

Figure 2. Logic data is captured and sent to a PC where it can be displayed.



The Ultimate Utility Meter is Born

This is a large project, and I will present it in two parts. In Part 1, I will show you the construction of the basic components. When it's complete, you will have a working serial graphics LCD that you can start experimenting with.

In Part 2, we will delve into the software, and I will lay out a complete set of operation instructions, as well as a few real-world examples.

Okay, we have a lot to do, so let's get started. I will provide a parts list at the end of the article with a complete listing of all the components I used to build the UUM.

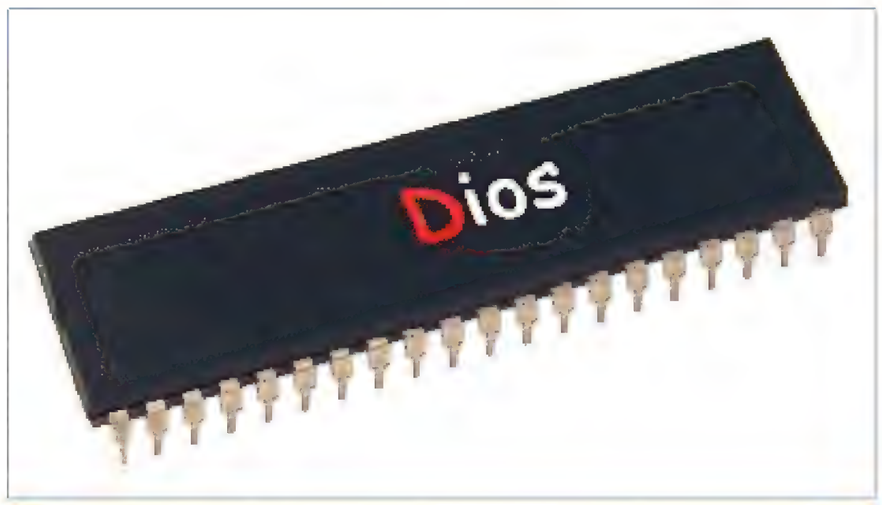


Figure 3. The Dios microcontrollers are the heart of the UUM.

Figure 4. One of the microcontrollers controls this Crystalfontz graphic LCD.

Construction

Two Dios microcontrollers are at the heart of the UUM (see Figure 3). These microcontrollers are connected via a hardware universal asynchronous receiver/transmitter (UART) in each chip, running at 115,200 baud. You don't need a programmer for these chips; just download the free compiler from the Kronos Robotics website (**www.kronosrobotics.com**).

The first Dios is a 40-pin microcontroller that controls the Crystalfontz CFAG12864B-YYH-V graphic LCD shown in Figure 4. This LCD has a 128 x 64 resolution and its own negative voltage generator, so interfacing is very straightforward. This Dios is also connected to a hex keypad. This assembly makes up the serial graphic LCD module.

Note: You may also use the Crystalfontz CFAG12864B-TMI-V

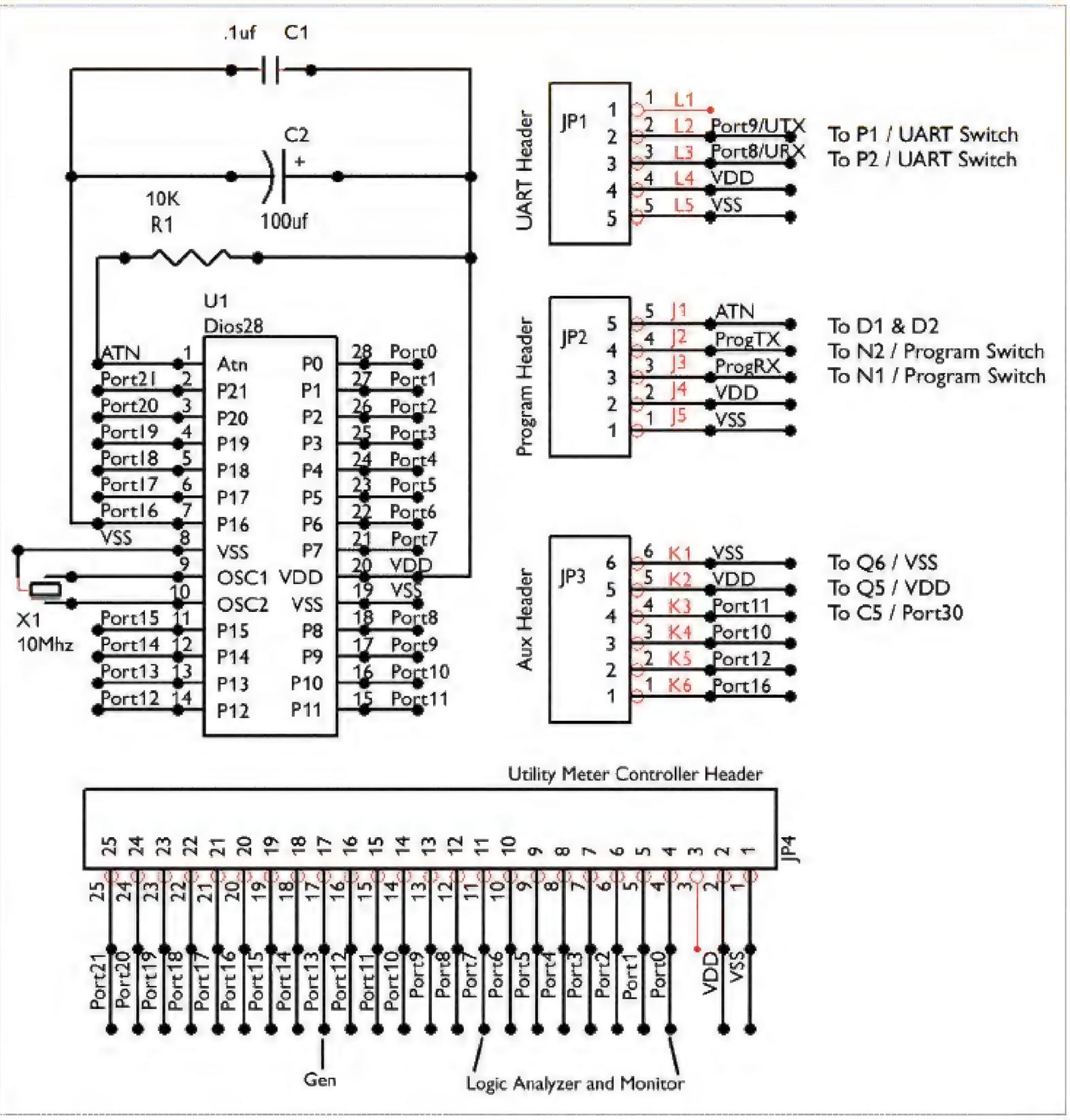
To simplify construction, I used a special carrier called a Dios Universal LCD Carrier. This carrier board is sold as a kit from Kronos Robotics and features a built-in regulator and PC interface, as well as a header for the Crystalfontz graphic LCD. You don't have to use the carrier, but it will make hookup and assembly easier.

The second Dios is used as the logic analyzer and signal generator. It sends commands to the serial graphic LCD to display all data, and it receives data from the serial graphics LCD when a key is hit on the keypad. This assembly makes up the utility controller module.

Again, I used a carrier to simplify the hookup. Here, we used the Dios Utility Carrier. This carrier comes with lots of extra headers that can be used for different applications. It even comes with its own mounting hardware.

I chose to use the Dios for this project for various reasons, but the most important reason is the raw power of the Dios. The Dios can run 130,000 to 200,000 high-level commands per second in the Basic language, and with inline assembly, it can run 10,000,000 instructions per second.

Schematic 1. The schematic for a more personalized carrier board.



By the Numbers

These instructions are directed at those using the two previously mentioned carrier boards. If you decide to use your own boards, use the provided schematics (Schematics 1 through 3). I have highlighted the jumpers in red to make it a bit easier for you.

Step 1: Assemble the Dios Universal LCD Carrier

Assemble the Dios Universal LCD Carrier according to the provided instructions. Insert the 40-pin Dios chip and set the jumpers as indicated for a graphic LCD. Make sure the notch in the chip is facing to the right, as shown in Figure 5.

Step 2: Test the Carrier

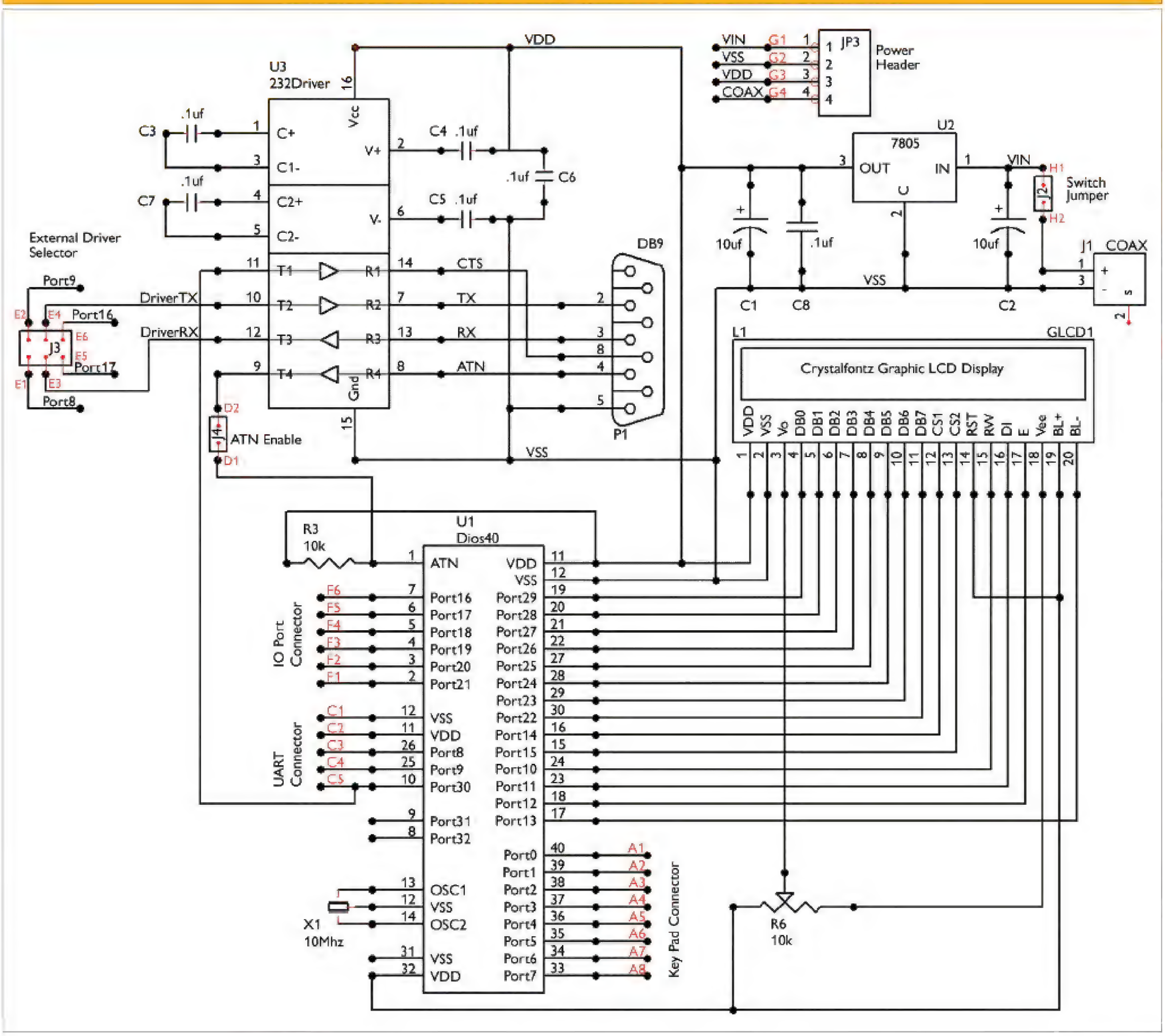
Install the Dios compiler, if you have not already done so, and connect a nine-pin serial cable. Load the Dios compiler and hit F6 to load the debug terminal. Power up the carrier. Once the carrier has power, it will begin sending test messages to the debug terminal.

Tip: A new Dios comes already programmed with the test program.

Locate the program file called "firsttest.txt" in the examples directory and load it into the editor. Program the Dios. Again, you should see the test data, and if all went well, you will have a working Dios Universal LCD Carrier.

Step 3: Assemble the Utility Carrier

Schematic 2. The jumpers are highlighted in red here and in Schematic 1.



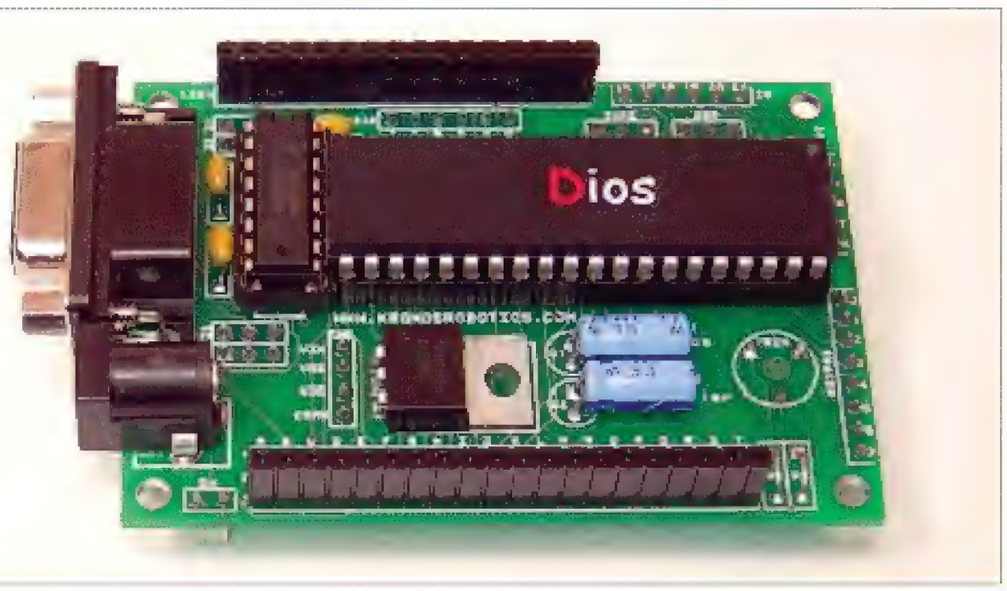


Figure 5. Assemble the Dios Universal LCD Carrier as shown.

Assemble the Dios Utility Carrier according to the provided instructions. The Dios Utility Carrier comes with multiple headers. Install them as shown in Figure 6. Use a 25-pin right angle for the main header and straight headers for the others. Insert the 28-pin Dios chip and set the jumper as shown in Figure 6.

Step 4:

At this point, we are ready to mount our carrier boards, switches, and keypad. I like to use what I call the sandwich enclosure technique. This is where you take two pieces of acrylic or compressed PVC and attach them with spacers as shown in Figure 7.

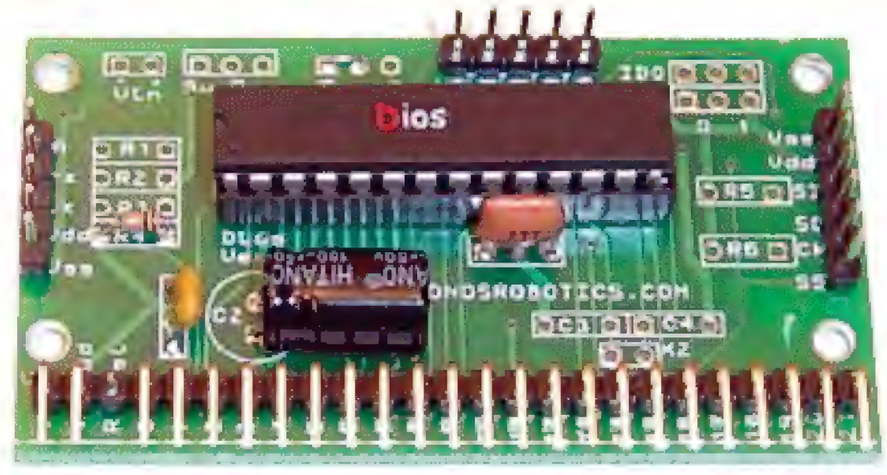
There are advantages to using clear acrylic over compressed PVC. For one, you don't need to create a cutout for the LCD. You can mount the LCD under the top sheet. It also makes it very easy to mark the locations for all the mounting holes.

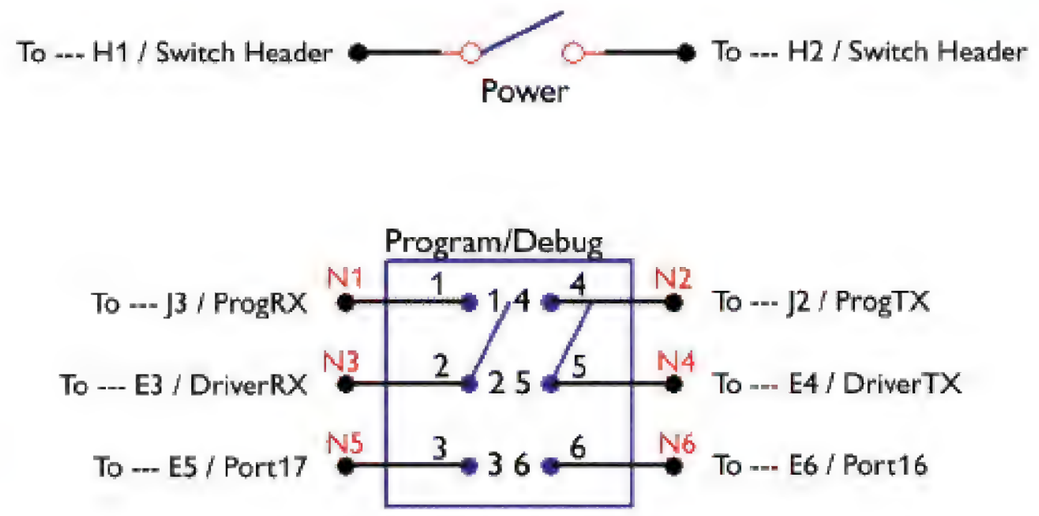
Start by creating the top panel out of a 4 x 7 x 1/8-inch sheet as shown in Figure 8. You can purchase acrylic from your local home center, where you might get it cut to size. All the holes are the same for both acrylic and PVC mounting.

For PVC, you will need to make the LCD cutout, as well as the keypad cutout. I used a scroll saw to make these. Once the cutout is made, fit the LCD and then mark your mounting holes. These holes are 1/8 inch in diameter. The keypad cutout shown is only for the All Electronics keypads called out in the Parts List. Any other keypad will require you to mark and cut a hole for that keypad. If you don't want to make the keypad cutout, you may also mount the keypad on top of the panel with a slot cut for the header.

For acrylic, things are a bit different if you want to

Figure 6. Use a 28-pin Dios chip for the utility carrier.





Schematic 3. A look at the three switches.

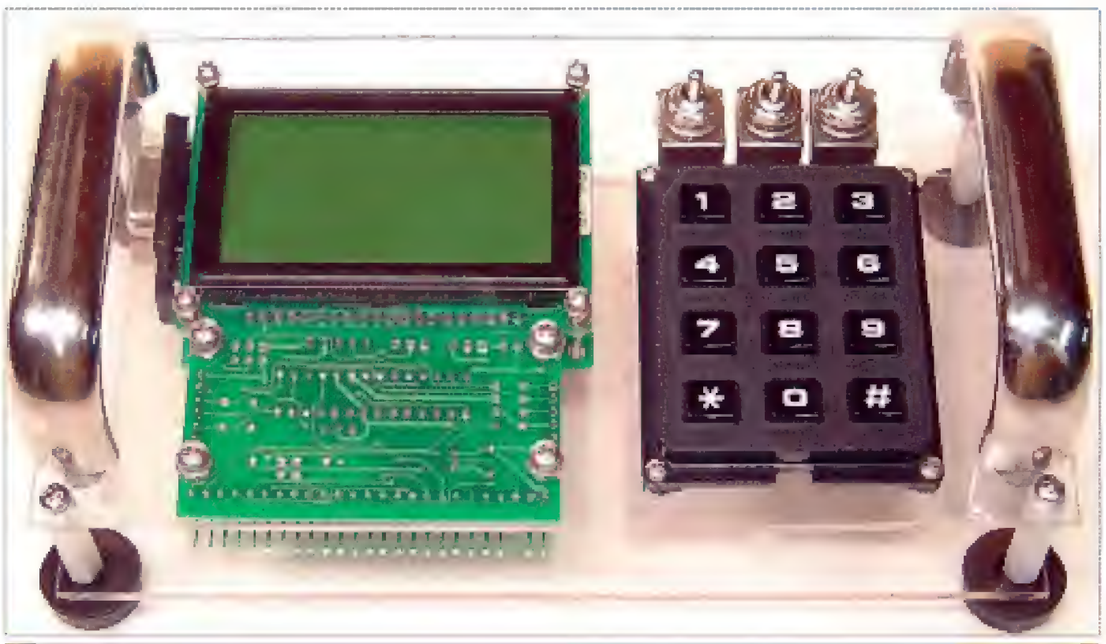


Figure 7. Use spacers to separate the two mounting acrylic pieces.

mount the LCD on the underside of the panel. Place the LCD under the panel and mark the four 1/8-inch holes.

If you want to mount the keypad on top of the panel, you only need to cut a small slit for the connector header to fit into. You can do this with a series of holes. Once the keypad is in place, you can mark the holes needed for mounting. The Universal LCD Carrier has a mounting kit available that has all the hardware to mount the LCD Carrier and a keypad. It also includes mounting instructions.

If you decide you don't want handles, you should not drill the 1/4-inch handle holes. I like the handles, as they give me something to grab when I move the UUM. They also help protect the LCD and switches if the UUM is dropped, but most importantly, they look cool.

Step 5:

Use the top panel as a template to mark the spacer holes on the bottom panel. These are 1/8-inch holes, as well.

Step 6:

Mount the LCD to the board. Use two 1/2-inch #2 machine screws on the rear and two one-inch #2 screws on the front. Note that the LCD does not come with a header. The Universal LCD Carrier comes with a male header that mates with the female installed on the carrier. Install this header on the LCD per the instructions that come with the carrier.

It's important that you use the proper spacers under the LCD, which vary, depending on how you are mounting it. For the cutout, a single #2 nut and nylon spacer is used. I recommend the Universal LCD mounting kit, as all the hard-to-locate hardware is included.

We are not attaching the Universal LCD Carrier to the LCD at this time. We will do that later.

Step 7:

Shown in Figure 9 is a 3 x 4-matrix keypad. Only seven of the eight pins on the keypad are used. All Electronics has two keypads that work perfectly and have the same size footprint. Circuit Specialists also sells a keypad that will work with only a slight change in size and footprint.

Mount the keypad to the panel as shown in Figure 10.

Step 8:

Mount the Utility Carrier to the panel with the included mounting hardware. The carrier comes with mounting instructions.

Step 9:

Mount the three switches as shown in Figure 10. The first switch can be an SPST or an SPDT switch. It's used as an on/off switch. The two red switches shown in Figure 11 are DPDT on/off/on three-position switches. Circuit Specialists sells these three-position switches.

Step 10:

You have a few choices regarding handles. All Electronics and Jameco both sell rack handles. The handles shown in Figure 7 are from Jameco, Part #216821. They don't come with mounting

Figure 8. The top panel follows this layout using a 4 x 7 x 1/8-inch sheet of acrylic.

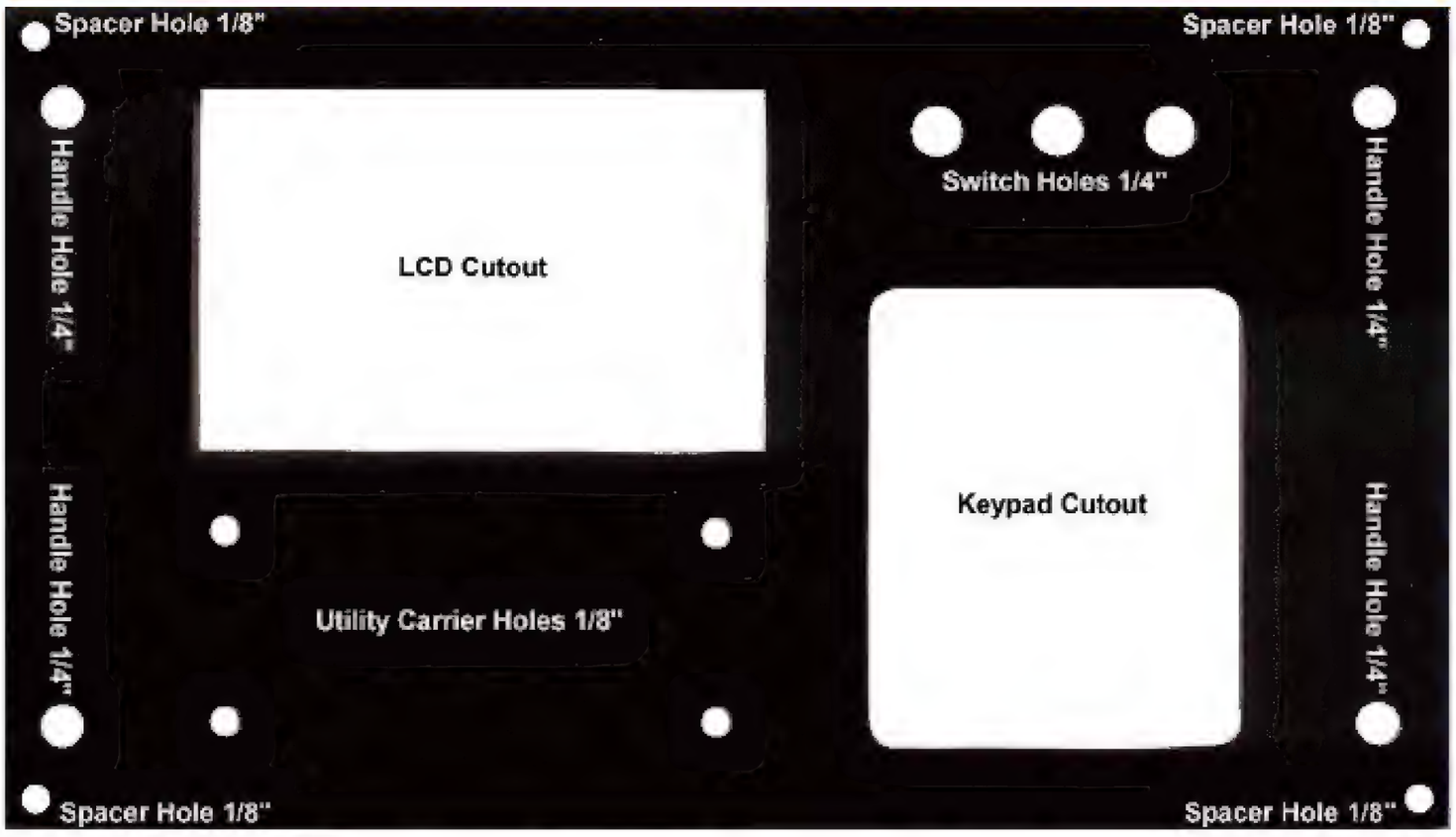


Figure 9. A typical keypad.

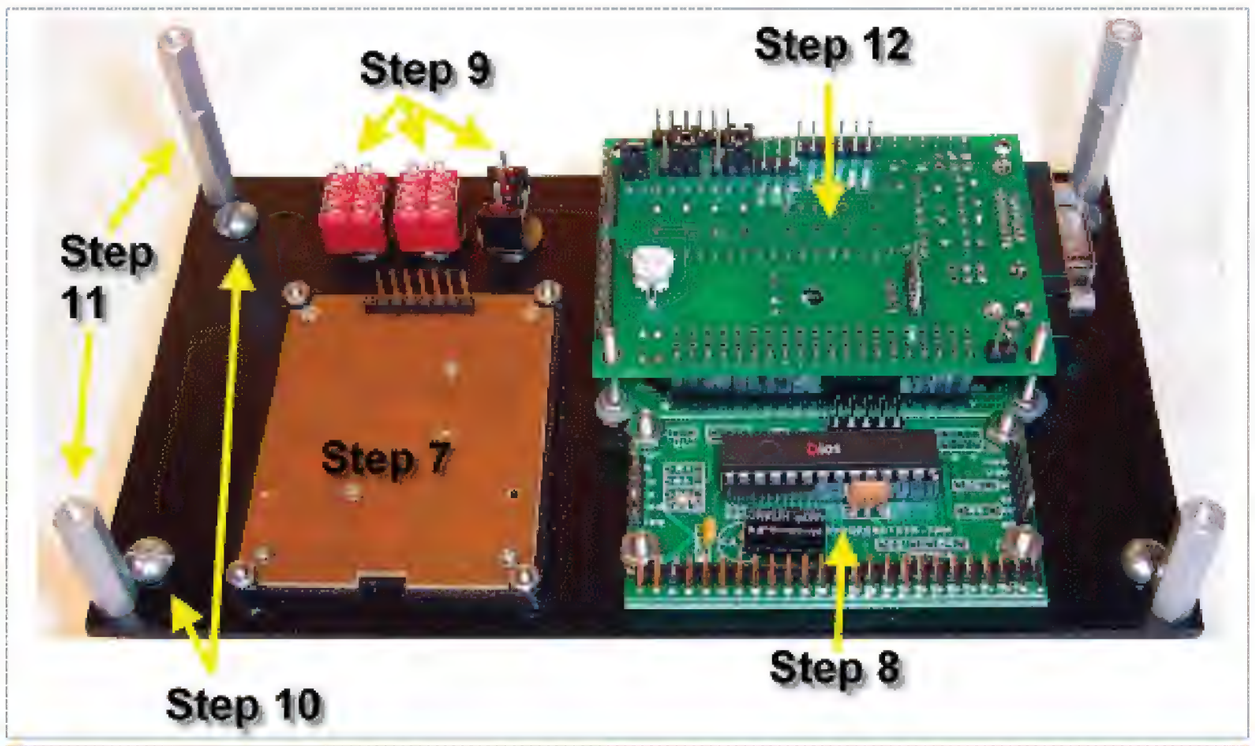


Figure 10. From the underside, the hardware mounting sequence.

Figure 11. The three switches used on the UUM.

screws, so you will have to pick up some 1/2-inch 10/32 machine screws from your home center.

I prefer to use three-inch cabinet handles, shown in Figure 12. They can be purchased for as little as $1.00 each and come with mounting hardware.

Step 11:

I used two one-inch spacers on the front and two one-inch and two 5/8-inch spacers on the rear. This will give the meter a nice slant that will make it much easier to use. The spacers shown in Figure 13 can be purchased from Jameco Electronics.

Using four #4 3/8-inch machine screws, attach the four one-inch spacers to the top panel. Attach the two 5/8-inch spacers to the two spacers at the rear, as shown in Figure 10.

Step 12:

Mount the Universal LCD Carrier on the LCD, as shown in Figure 10. The carrier must be plugged into the header and fitted over the two front one-inch #2 machine screws. Once attached, hold it in place with a couple of nylon washers and lock nuts.

Step 13:

All components are in place, and it's time to jumper a few of the headers. You can solder wires to the headers if you wish, but I prefer to take the time and make actual jumpers. The jumpers can be removed later, if necessary, to allow updates and changes to the hardware.

To make a header jumper, you need to use a female header. I use snapable headers and remember to cut the header so you have the correct number of pins.

Strip the end of the jumper wire. I like using ribbon cable so I can peel off the number of wires needed. Place a piece of 1/4-inch-long heatshrink on the ends as shown in Figure 14.

Solder the wires to the header and slip the heatshrink over the connections. Apply some heat and you have one end of your jumper.

I will list each jumper used to connect the various switches and carriers to each other. The jumper locations have been highlighted on the schematic in red. I have included a picture of the actual jumper locations in Figures 16 through 18.

Jumper 1

M3 ——————— H1
M2 ——————— H2

Solder two wires to the SPST switch. Connect the

Figure 12. Handles are attractive and cheap.

Figure 13. Use spacers for a slanted look.

Figure 14. Heatshrink the ends of the wires.

Figure 15. Heatshrinking provides a clean look.

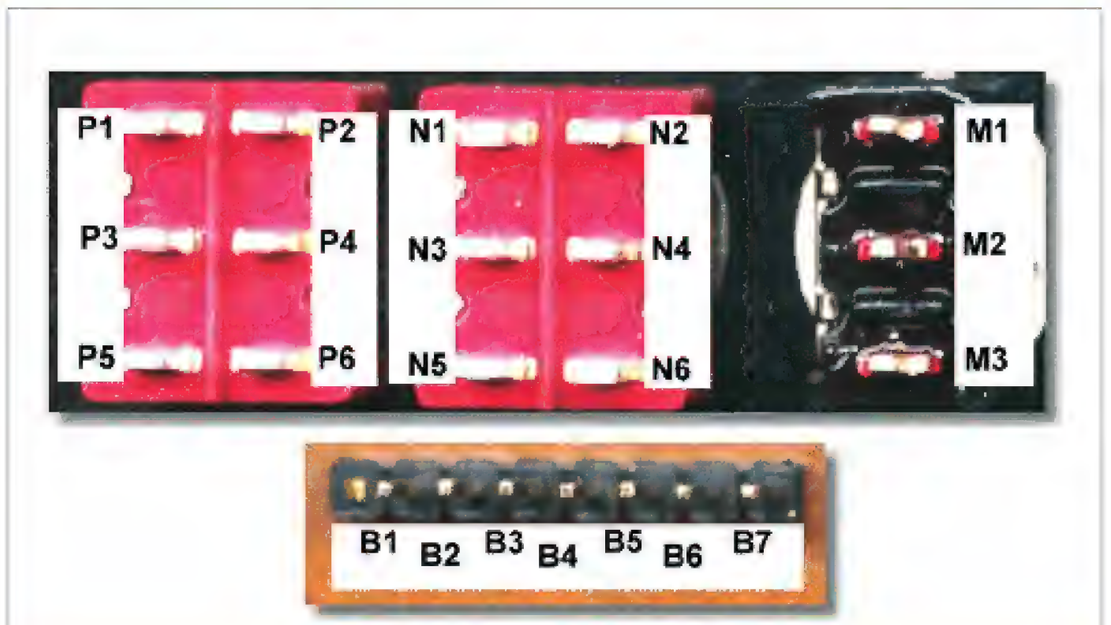


Figure 16. Jumper locations for the switches and keypad.

other end to the female jumper and then connect it to H1 and H2. Polarity is not important.

Jumper 2

N5 ———— E5
N6 ———— E6

Solder two wires to program switches N5 and N6. Connect the other end to a female jumper, then to E5 and E6. Double-check the placement of the leads.

Jumper 3

E3 ———— N3
E4 ———— N4
E3 ———— P5
E4 ———— P6

This is a unique jumper. Connect two wires to E3 and two wires to E4. One of the wires on E3 will connect to N3 and the other to P5. Connect two wires to E4. One of the wires on E4 will connect to N4 and the other to P6.

Jumper 4

Q5 ———— K2
Q6 ———— K1

This is a simple female jumper to female jumper configuration. This jumper provides power to the controller board.

Jumper 5

D1 and D2 ———— J1

Here, we take a two-pin female header and short the two leads together. Then, connect it to a single female jumper with one wire. This allows us to both short the jumper (enable the RS232 Reset) and route the reset to the controller board at the same time.

Jumper 6

N1 ———— J3
N2 ———— J2

Solder two wires to the program switch, then to a two-pin female header. This is the program/debug port for the controller board J3 and J2.

Jumper 7

P3 ———— E1
P4 ———— E2

Solder two wires to the UART switch and then to a two-pin

Parts List

Qty	Description	Source and part number
1	Dios 40-pin Microcontroller	Kronos Robotics #16168
1	Dios 28-pin Microcontroller	Kronos Robotics #16169
1	Dios Universal LCD Carrier	Kronos Robotics #16410
1	Crystalfontz Graphic LCD	CFAG12864B-YYH-V or CFAG12864B-TMI-V
1	Universal LCD Carrier Mounting Hardware	Kronos Robotics #16430
1	Dios Utility Carrier	Kronos Robotics #16431
2	1/8-inch Panels, 4 x 7 or 5 x 7 inches	Expanded PVC 5 x 7 inch black Kronos Robotics #16432 or Plexi-Glass or equivalent from local home center
2	Three-inch Handles	Jameco #216821 or All Electronics # HDL-32 or three-inch cabinet handles from local home center
2	Miniature DPDT Three-position Switches	Circuit Specialists #8012
1	Miniature SPDT Switch	Kronos Robotics #16241 or All Electronics #MTS-4
1	Matrix Keypad	All Electronics #KP-26 or #KP-28 or Circuit Specialists #KIT A1
4	Aluminum Spacers 4-40 Threads F-F	Jameco #139205
2	Aluminum Spacers 4-40 Threads M-F	Jameco #139213
8	4-40 1/2-inch Machine Screws	Jameco #106809
4	Rubber Feet	Jameco #119618
2	36-Pin Female Headers (Snapable)	Kronos Robotics #16291
1	Hookup Wire (10 feet Ribbon Cable)	Jameco #112547
5	1/16-inch Heatshrink Strips	Kronos Robotics #16287
1	Dios Compiler	Free download from Kronos Robotics website at **www.kronos robotics.com**
1	AC Adapter 7-12V	Kronos Robotics #16305 or any AC adapter with 2.1 ID and 2.5 OD center positive.

female header and connect them to E1 and E2.

Jumper 8

P1 ———————— L2
P2 ———————— L3

Solder two wires to the UART switch and to a two-pin female header and connect them to L2 and L3.

Jumper 9

C5 ———————— K3

Connect the single one-pin, female-to-female header.

Jumper 10

B1 through B7 to A1 through A7

Connect seven pins, B1 through B7, to A1 through A7 via a seven-pin, female-to-female header.

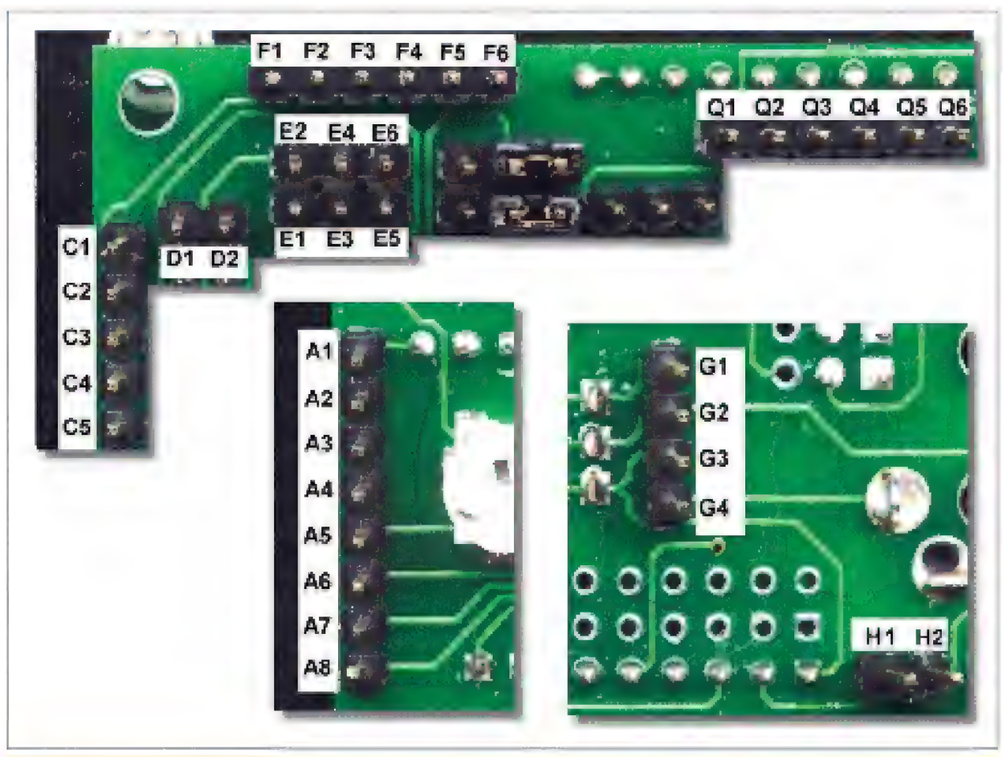


Figure 17. Jumper locations for the serial graphic LCD module.

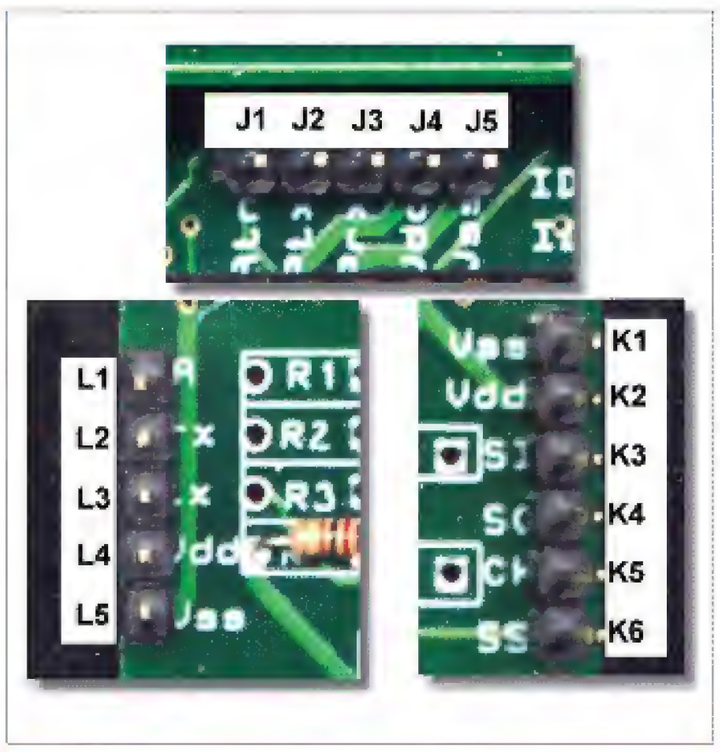


Figure 18. Jumper locations for the utility module.

This concludes all the jumper connections. We are now ready to load up some software and perform some basic tests.

Step 14:

Load the Dios compiler and connect a nine-pin serial cable from the UUM to the PC. Figure 19 shows the three

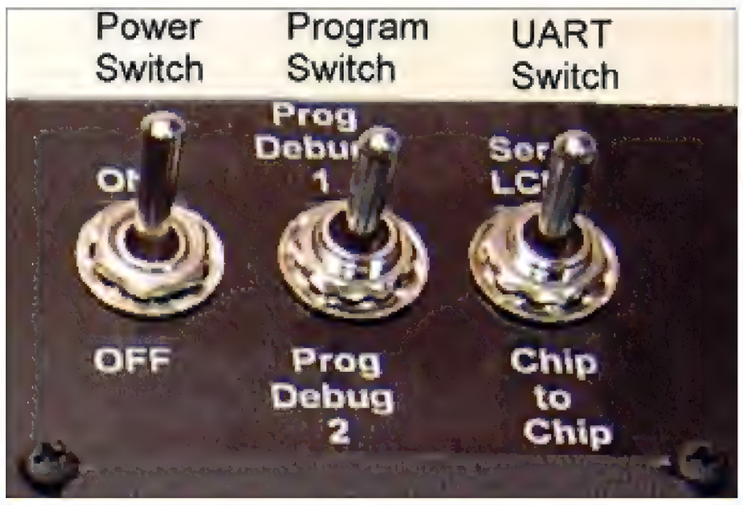


Figure 19. The switch location and orientation.

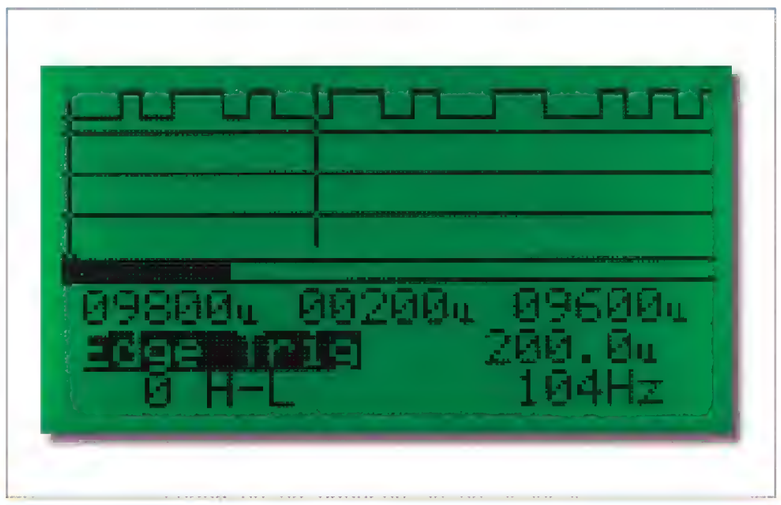


Figure 20. The pulse of a Skyfi2 XM radio remote.

UUM switches. Set them to the following:

Power = On (up)
Program = 1 (up)
UART= None (middle)

This sets up the serial graphic LCD module to be programmed.

Locate the test program you loaded in Step 2 and program the chip. The test messages will display in the compiler debug window, and the backlight on the LCD will begin to flash.

All of the UUM software is included with the Dios compiler. Locate the "UUMSerLCD.txt" program. It is in the projects\UUM directory where you installed the compiler. Now, program this file into the Dios.

You should see the following message:

UUM Serial LCD
115200 Baud
V1.0

You may have to adjust the contrast trimmer if the information is not displayed. At this point, you can set the UART switch to Ser LCD mode (up). This will allow you to send commands to the serial graphic LCD from the PC. The complete list of commands can be downloaded from the Kronos Robotics website.

Step 15:

Set the switches to the following:

Power = On (up)
Program = 2 (down)
UART= Chip to chip (down)

This sets up the utility module to be programmed. Now locate the "UUM.txt" program in the projects\UUM directory and program the utility module. You should see the display change to the main UUM display.

Step 16:

Install the bottom panel with four 3/8-inch machine screws. You now have a complete and working UUM.

In Part 2, I will present you with a complete operations manual and show you a few examples of how to operate the UUM. At this point, you should have enough information to start playing with the UUM. Check out the serial graphic LCD instructions and use the debug terminal to display text and graphics on the LCD from your PC.

As a teaser, take a look at Figure 20. Using a Vishay IR Sensor or IR photo transistor on one of the analyzer ports, we can read the pulses of just about any IR remote pulse train. In this case, it's the output of a Skyfi2 XM Radio IR remote and key. We will dig into many more examples next month. NV

Sources

The Kronos Robotics website:
www.kronosrobotics.com

The Jameco website:
www.jameco.com

The All Electronics website:
www.allelectronics.com

The Circuit Specialists website:
www.web-tronics.com

The Crystalfontz website:
www.crystalfontz.com

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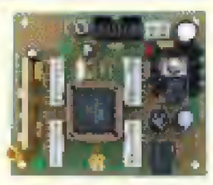

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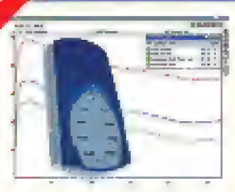

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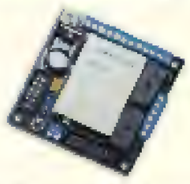

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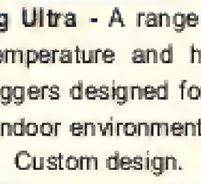

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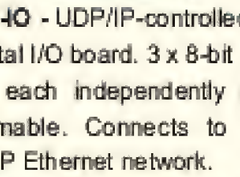

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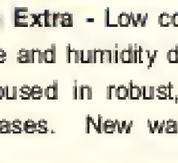

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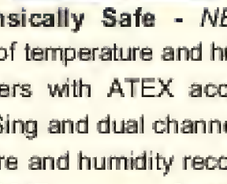

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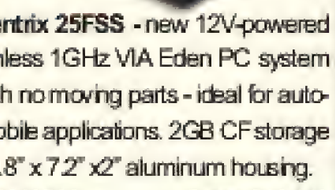

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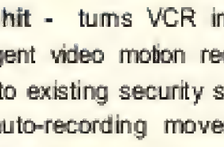

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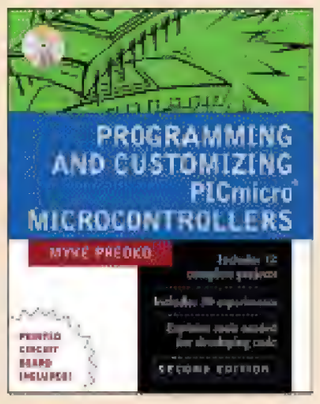

This book is a fully updated and revised compendium of PIC programming information. Comprehensive coverage of the PICMicros' hardware architecture and software schemes will complement the host of experiments and projects making this a true "learn as you go" tutorial. New sections on basic electronics and basic programming have been added for less sophisticated users, along with 10 new projects and 20 new experiments. The CD-ROM contains all source code presented in the book, software tools designed by Microchip and third party vendors for applications, and the complete data sheets for the PIC family in PDF format. **$49.95**

OOP Demystified
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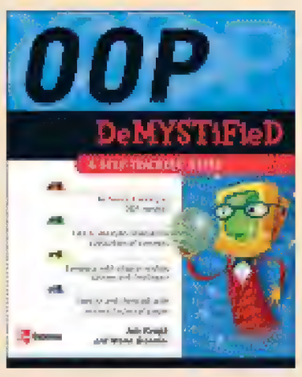

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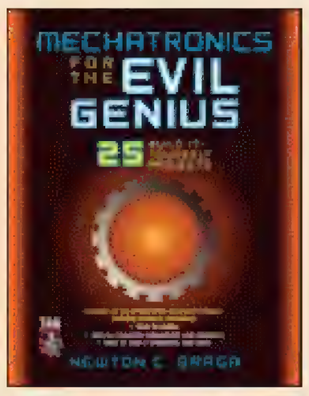
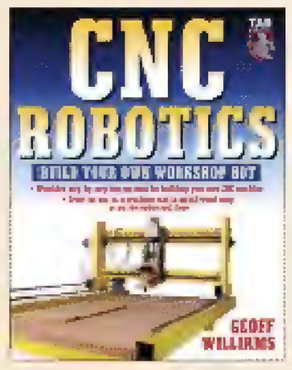
Robotics

Mechatronics for the Evil Genius
by Newton C. Braga



The popular evil genius format provides hobbyists with a fun and inexpensive way to learn Mechatronics (the merger of electronics and mechanics) via 25 complete projects. The projects include a mechanical race car, combat robot, ionic motor, electromagnet, robotic arm, light beam remote control, and more. Also included are parts lists and a tool bin for each project. *Mechatronics for the Evil Genius* covers all the preparation needed to begin building, such as how to solder, how to recognize components and diagrams, how to read a schematic, etc. **$24.95**

CNC Robotics
by Geoff Williams



Written by an accomplished workshop bot designer/builder, *CNC Robotics* gives you step-by-step, illustrated directions for designing, constructing, and testing a fully functional CNC robot that saves you 80% of the price of an off-the-shelf bot — and can be customized to suit your purposes exactly because you designed it. **$34.95**

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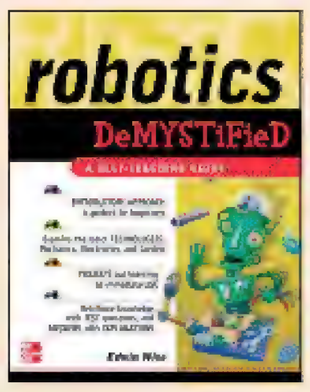
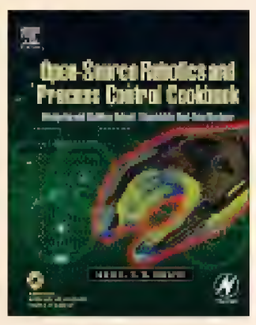


McGraw-Hill's *Demystified* titles are the most efficient, interestingly written brush-ups you can find. Organized as self-teaching guides, they come complete with key points, background information, questions at the end of each chapter, and even final exams. This complete self-teaching guide takes an introductory approach to robotics, guiding readers through the essential electronics, mechanics, and programming skills necessary to build their own robot. **$19.95**

Open-Source Robotics and Process Control Cookbook
by Lewin Edwards



In this guide, Lewin Edwards demonstrates efficient and low-cost open source design techniques, covering end-to-end robotic/process control systems using Linux as the development platform, with extensive information on free compilers and other tools. Specifically, the book targets development of real-time physical system controls using Atmel AVR microcontrollers communicating with Linux-based PCs for overmonitoring. Code examples are given to provide illustrations of tasks described in the text. The CD-ROM contains all the code used in the design examples, as well as useful open-source tools for robotics and process control system design. **$49.95**

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by Paul Scherz

The first edition of *Practical Electronics for Inventors* was phenomenally successful and popular among electronics hobbyists and "tinkerers." This is a fairly "tight" group, and when they noticed some errors in the book, they were fairly vocal in wanting to see errata. The result? A new and improved book that has been completely updated, with several readers' suggestions for improvement incorporated inside. These new additions will make this title even MORE appealing to the loyal market. **$39.95**

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by Gene McWhorter / Alvis J. Evans

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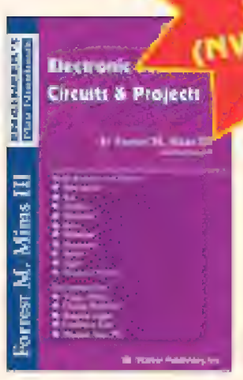

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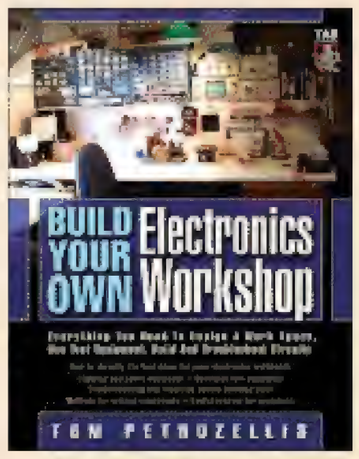

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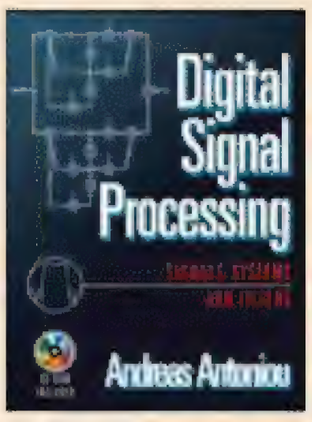

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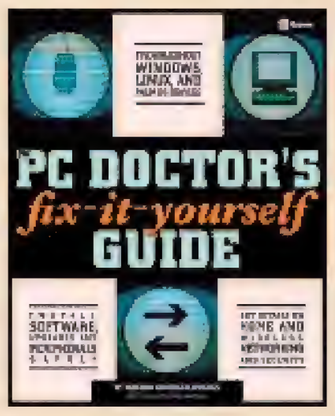
by Adrian Kingsley-Hughes



In *The PC Doctor's Fix It Yourself Guide*, you get advice and solutions for solving a myriad of PC problems, including expert tips on researching solutions on your own. Learn how to maintain your computer, keeping it in good working condition, and how to upgrade and install new software safely. Troubleshoot Linux, Windows, and personal devices, use the Internet effectively as a problem-solving tool, get up to speed on computer security, and set up small home and wireless networks. The companion website provides additional support. **$29.99**

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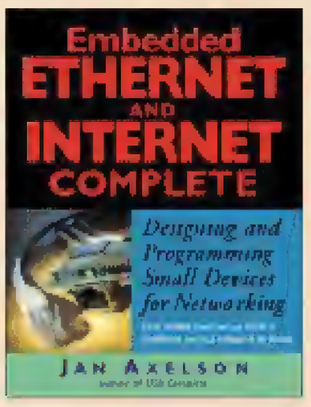

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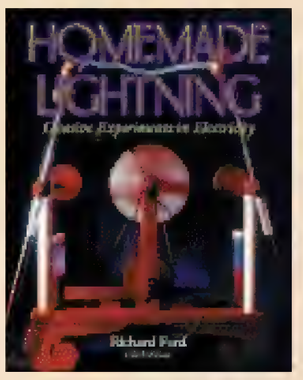

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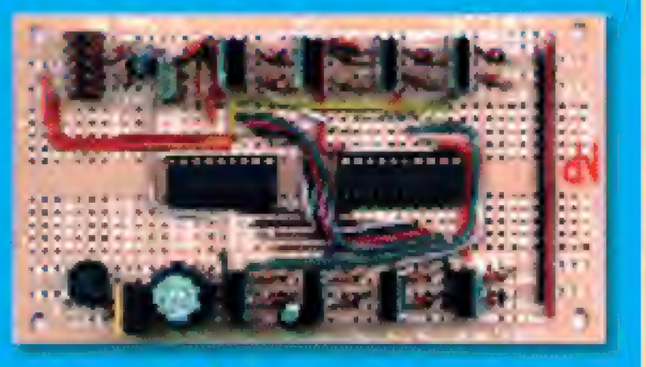

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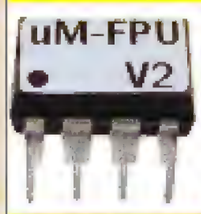

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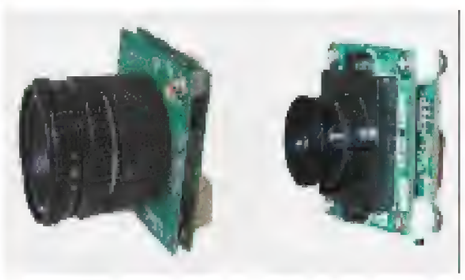
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News Bytes

ProcessLibrary.com On Track to Serve Up 100,000,000 Solutions in 2005

Uniblue Systems Ltd. has updated ProcessLibrary.com — a free, content-rich website full of information about the spyware, adware, Trojan, and virus threats to Windows, as well as information about Windows system processes and common applications. Since its launch in September of 2004, ProcessLibrary.com has added more than 2,500 process definitions. ProcessLibrary.com enjoys more than 300,000 individual searches per day, and has become a vital resource for people who want to protect themselves against virus attacks, privacy invasions, and other online threats.

Firewalls and anti-virus software are necessary tools for keeping your PC safe. To supplement these security tools, ProcessLibrary.com has information about the invisible processes that run silently on your computer every time you start Windows. Some of these programs

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hog system resources, stealing your productivity and making your system sluggish. Worse yet, other processes hide spyware and Trojans, violating your privacy and opening the door for hackers to gain access to your passwords, credit card numbers, and other sensitive personal information. ProcessLibrary.com is a free resource that shines a light on all of your Windows processes.

By pressing ctl-alt-del in Windows, you can look at a list of every process that is running on your computer. Typing the name of any process into ProcessLibrary.com's search box will give you a detailed description of the process, the name of the author and the software package that it is associated with, the type of process (system, application, virus, Trojan, spyware), and information about how it will affect your computer.

The website also offers a search engine of DLL information. Every Windows computer has hundreds of DLL programs. Most are harmless. ProcessLibrary.com will tell you what each program is, who created it, why it's on your hard drive, and what you should do with it.

Webmasters who want to give their visitors information about Windows processes can link their sites directly to ProcessLibrary.com and display the Top 5 most popular processes, the Top 5 security threats, and the Top 5 newly discovered processes.

With millions of page views every month, **www.processlibrary.com** has grown to become the primary reference point for thousands of users around the globe. Processlibrary.com is featured on a large number of sites and in *USA Today*, Yahoo!, and *The Washington Post*.

The extensive database available on ProcessLibrary.com is part of the WinTasks 5 Pro application from Uniblue Systems Ltd. WinTasks 5 Pro can identify and remove the unwanted processes that are running on any Windows computer.

For more information about ProcessLibrary.com, contact Kevin J Vella at kevinjv@uniblue.net.

BEST, Inc., and Partners Announce Lead Free Rework Training Course

BEST Inc., in conjunction with its project partners, Cookson Electronics Assembly Materials and Automated Learning Corp., now offer a "*Lead Free Rework*" assembly training course. This interactive multimedia learning course — which allows the student to learn the material at a time convenient for them — is designed for rework technicians, process engineers, and repair depot technicians and their respective managers who are involved in the rework of lead-free electronic assemblies.

As part of the suite of lead-free assembly courses, the Lead Free Rework course teaches key concepts through presentation, practice, and testing of the material. The learning takes place at any time or place that is conducive for the student. Learning is assured through a final

interactive test for certification of the concepts learned in the program. This course can be conducted either over a company LAN or through the Internet, allowing the student to learn on their own time and at their own pace. Translated versions will be offered initially in German and Chinese.

"BEST and its partners have put together a highly informative rework training program. This material augmented with BEST's hands-on instruction in lead free rework techniques will prepare rework and hand soldering technicians for the challenges of lead free rework," said Bob Wettermann of BEST, Inc.

As companies are discovering as they shift to lead free production, the move requires planning, time, and management of key challenges. Proper training in lead free technologies and practices can help accelerate a company's ability to make the transition. Learntech® training courses incorporate interactive learning checks throughout the instructional sequences and include a criterion-referenced and module-based test, with feedback on every response for enhanced learning.

Business Electronics Soldering Technologies (BEST) specializes in offering products that streamline hand soldering, rework, and repair, which also includes lead free soldering products. BEST is an IPC Certified Center offering Instructor and Operator soldering courses for IPC-A-610, JSTD-001, IPC 7711/7721, as well as customized classes to meet specific standards or criteria. For more information, visit **www.solder.net**

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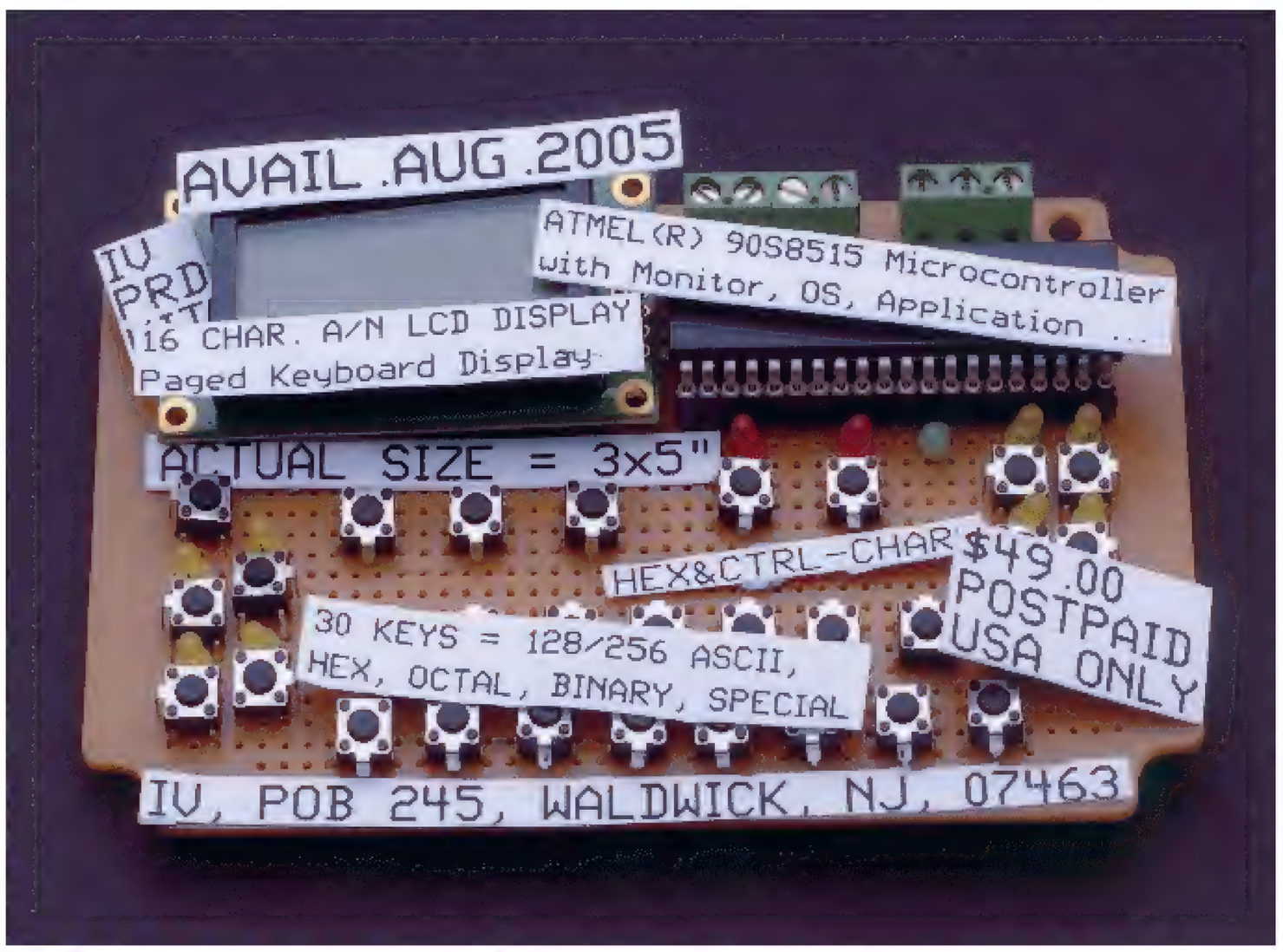


Japan Unveils Robot Suit

Japan has taken a step into the science-fiction world with the release of a "robot suit" that can help workers lift heavy loads or assist people with disabilities climb stairs.

"Humans may be able to mutate into supermen in the near future," said Yoshiyuki Sankai, professor and engineer at Tsukuba University who led the project.

The 15-kilogram (33-pound) battery-powered suit, code-named HAL-5, detects muscle movements through electrical-signal flows on the skin surface and then amplifies them.

It can also move on its own accord, enabling it to help elderly or handicapped people walk, developers said. The prototype suit will be displayed at the World Exposition taking place central Japan.

(Someone should tell these guys about Tetsujin 2005! See Page 104.)

World's Biggest Hacker Held

A London man described as the "world's biggest computer hacker" has been arrested.

Gary McKinnon, 39, was seized by the Met's extradition unit at his Wood Green home.

The unemployed, former computer engineer is accused of causing the US government $1 billion of damage by breaking into its most secure computers at the Pentagon and Nasa. He is likely to be extradited to America to face eight counts of computer crime in 14 states and could be jailed for 70 years.

BLOG

Your New Home on the Internet Awaits

by Edward Driscoll, Jr.

http://www.

On the Internet, 2004 seemed to be the year of the Weblog. *Time Magazine* even created a new category for them for their traditional year-end "Man of the Year" issue, and handed out their first "Blog of the Year" award.

There are now over seven million Weblogs — more than the number of readers of the *New York Times*, or viewers of CNN or Fox News. (Before I forget, my blog is at the eponymously titled **www.eddriscoll.com**.) A few years ago, a blogger named William Quick of **www.dailypundit.com** coined the term "The Blogosphere" to somewhat humorously refer to this ever-expanding universe of Weblogs.

But it took quite a while for the Blogosphere to reach its current plateau — and as you'll eventually see, there is room for more — including you.

Why would you want a Weblog? The reasons why people start them are as varied as blogs themselves. Many listen to Peter Jennings or Bill O'Reilly on TV, disagree with their take on events, and rather than throwing bricks at their TVs, start typing into their Weblogs. Others have thoughts on burgeoning new technologies, or have electronic projects of their own to share. Or they wish to criticize the movie or TV show they saw last night. Or they have photos or self-produced music or videos they'd like to expose to a wider audience.

A Lot of History in Less Than a Decade

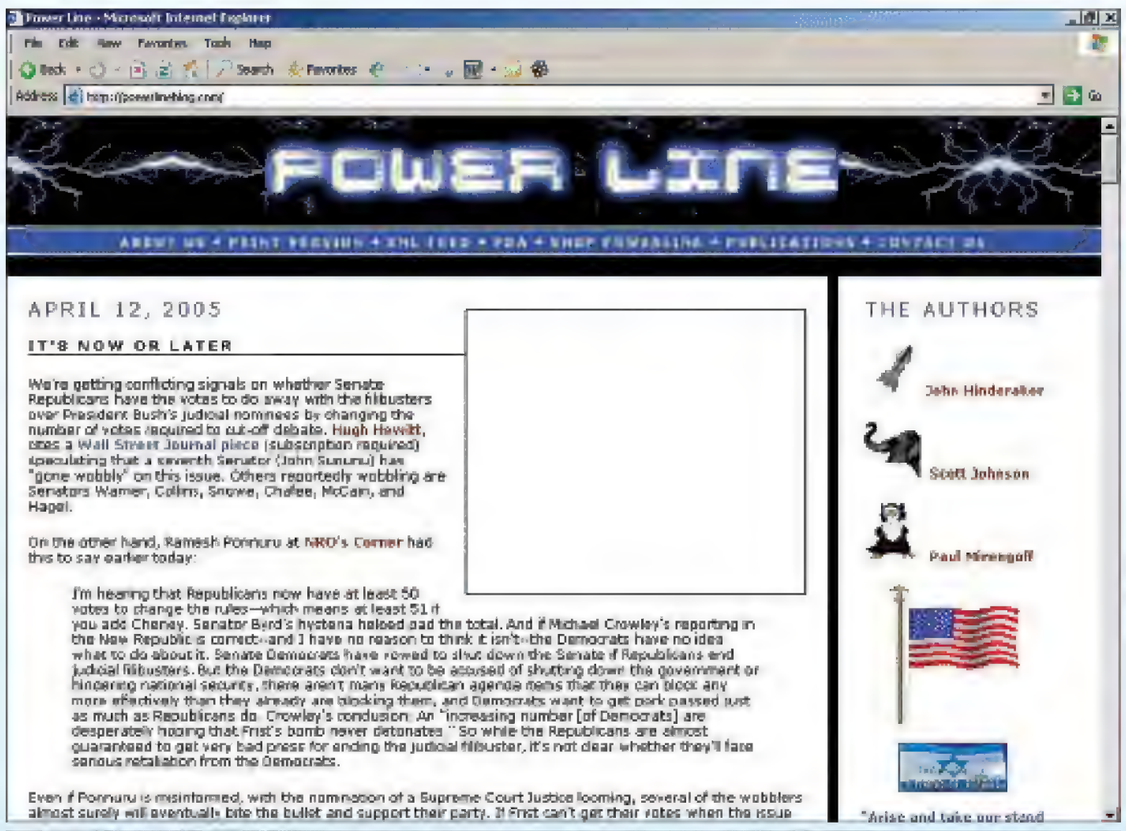
As you can see, Weblogs have evolved into a multifaceted platform designed to quickly and easily disseminate any idea their human owners want to share with others. But there are several interesting twists in their evolution. When the format debuted in the 1990s, many of the first blogs were online diaries, consisting of posts describing "day in the life" events and the author's thoughts about them. (Hence the "log" part of the now frequently contracted word Weblog, often shorted to simply blog.)

Beginning with September 11, 2001, Weblogs came of age as an entirely new medium, offering news and opinion. Because the magnitude of that day's events overwhelmed the servers of traditional news sites, many Internet readers stumbled across smaller one-man Weblogs who offered commentary based on what they were seeing on TV, presenting links to websites that appeared to be still online, and generally sort of directing online traffic that day.

Then, as the dust settled, media bias started rearing its ugly head again, especially in newspapers, where the reporters seemed to work from style guides left over from the Tet Offensive. Quagmire! Failure! Evil imperialism! The

Glenn Reynolds — popular blogger and creator of the **InstaPundit.com** weblog site.

InstaPundit.com — one of the most popular weblogs.



Power Line (**www.powerlineblog.com**) — run by three attorneys — was just one of the thousands of weblogs that was launched by **InstaPundit.com** *Time Magazine* named it 2004's "Blog of the Year."

brutal Afghanistan winter! Remember the Soviets!

Seeking fresh news and opinions that didn't seem to be outtakes from the Johnson years, an audience of Weblog readers began to build. And, in retrospect, sometimes it seems like everyone in that audience saw how much fun the bloggers were having and decided to get into the act themselves.

Meet Some Prominent Bloggers

One of the most prominent bloggers to gain notoriety on 9/11 and in the weeks immediately afterwards, was University of Tennessee Law Professor, Glenn Reynolds. Reynolds' **InstaPundit.com** site, which had only been online for a month prior to 9/11, immediately had a huge upswing in traffic, and now receives upwards of 175,000 visitors a day.

His Weblog — a mix of moderate to libertarian political views, commentary on news of the day, and discussions of his favorite hobbies (digital cameras, Wi-Fi, and recording music) — launched a thousand "blog children."

One of those was a Weblog called Power Line (**www.powerlineblog.com**), run by three attorneys (two based in Minneapolis, the third in Washington, DC). For their role in uncovering fabricated documents used by CBS, their Weblog was the one that was named 2004's "Blog of the Year" by *Time Magazine*.

Writing the Book on Blogs

Prior to becoming interested in blogging, some of the genre's most successful practitioners had written lots of material for what some bloggers, with tongue firmly in cheek, call "the legacy media;" in other words, those formats that preceded Weblogs.

One of the most successful to make the jump was radio talk show host and attorney, Hugh Hewitt, who has also been blogging for several years at **www.hughhewitt.com** In January 2005, he released a surprise best seller on the subject, called — naturally enough — *Blog* (Nelson Books, available from **Amazon.com** and numerous "bricks and mortar" booksellers). It's perhaps the most easily accessible book yet written on the Blogosphere — what it is, what it's accomplished, and where it's going. It's also unique in its discussion of Weblogs as a potential business tool.

Perhaps what makes Hewitt's book so user-friendly is that Hewitt is no great technophile himself. Unlike many authors of Internet-oriented books, Hewitt doesn't consider himself on the cutting edge of HTML code or XML feeds. James Lileks, the Minneapolis Star-Tribune columnist whose "Daily Bleat" online diary (**www.lileks.com**) is a Blogosphere favorite, is a frequent guest on Hewitt's show. Lileks once wrote that "Hugh's preferred method of putting pictures up on his website no doubt consists of taping them to the monitor face in, so we all can see them."

Hewitt doesn't argue with that description, saying with a chuckle, "I'm a total technological idiot. What I have is the ability to post, and I have a staff of web designers who got it to that point; and if the site breaks, I call them. All I know how to do is post and link. So I am as low-tech a blogger as there is out there."

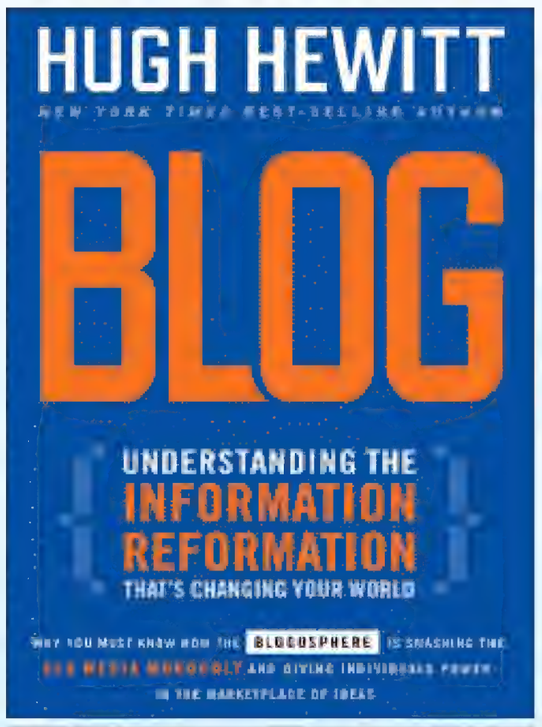
On the other hand, Hewitt feels that approach has actually been a plus in writing *Blog*. "It's a forest and trees thing," Hewitt adds. "The techno-wonks are all lost in 'the beauties of RSS feed,' and whether or not videoblogging is going to overwhelm conventional blogging.

I'm stepping back and looking at a new communications technology available to anyone with a nickel and a modem, and saying that that's got huge consequences."

How huge? Well, Hewitt compares Weblogs to Martin Luther's Protestant Reformation of the 16th century.

Isn't that a bit presumptuous? Is the Blogosphere really comparable to the Reformation?

"Absolutely," Hewitt says (and other bloggers have also used the analogy). "The Church lost control of the text, and once they did, especially with its translation into German, individual people began making decisions for themselves. Today, Big Media has lost control of the information flow, and the consequences are immediate and all around us."



Blog, written by Hugh Hewitt, is about the Blogosphere — what it is, what it's accomplished, and where it's going.

Hugh Hewitt — creator of the **hughhewitt.com** weblog site and author of *Blog*.

So What Makes a Weblog Tick?

The basic feature that a Weblog allows is virtually instantaneous (and very easy) uploading of a block of text in what is called a post. Unlike a magazine or newspaper — where physical requirements often dictate articles of a certain length — posts can vary in length from a single short sentence (often containing a hyperlink to a related lengthier article offsite) to a thousand words or more. A post can also be strictly a link to a photo, or an audio or video clip.

Traffic gets drawn to a Weblog from several sources, including friends and fellow bloggers. The other source of a Weblog's traffic is search engines. Search engines — particularly Google — love Weblogs, and as a Weblog accumulates posts on a variety of topics, new readers will find your Weblog when they are searching for information on the topics you've discussed.

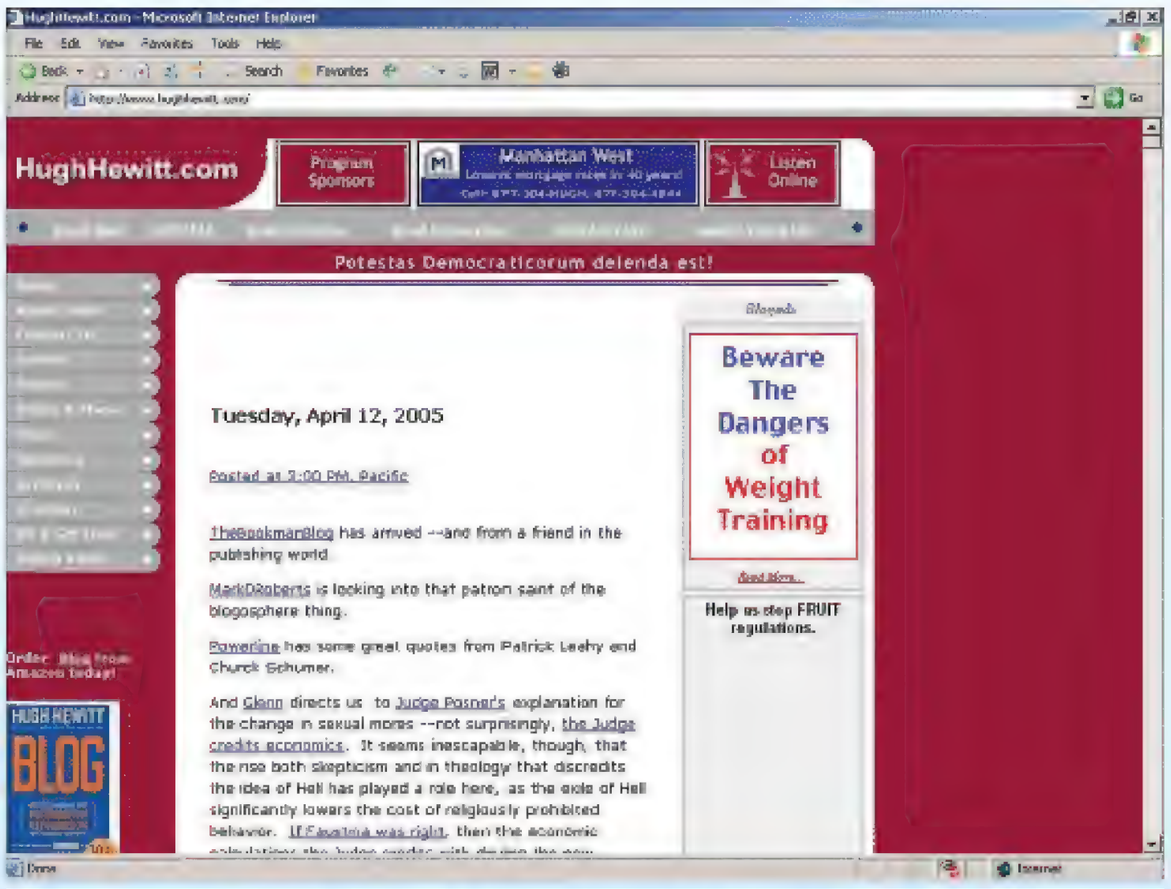
How to Start a Weblog

Starting a blog is astonishingly easy. There are a number of software platforms that facilitate it, but perhaps the two most popular are Blogger and Movable Type. Blogger (**www.blogger.com**), which was bought by Google in 2003, is perhaps the easiest of all. Enter a user name and password, select a template, and off you go. They'll even host it for free on their Blogspot domain. However, if you have some sort of website already, it's probably best to host the blog there, and simply use Blogger to enter data into it.

Movable Type (**www.sixapart.com/movabletype/**) is a more powerful alternative, and includes several features built-in that require additional installation to the basic Blogger software. But Moveable Type generally requires either professional installation, or at least prior knowledge of web programming.

Many of the most prominent blogs have begun on Blogger (and frequently hosted on Blogspot) before moving to running on Moveable Type on their own domains. Skilled web designers (such as Stacy Tabb of **Sekimori.com**) can frequently port over data created on other formats when updating to Moveable Type.

BLOG – Your New Home on the Internet Awaits



www.hughhewitt.com was created by Hugh Hewitt.

Should a Weblog Have Comments?

Online comments allow readers to immediately respond to a new post; frequently offering opinions, corrections (if warranted), and often links to related articles. It's possible for a short post by the owner of the blog to become a lengthy dialogue with his readers. When a large enough readership causes comments to get extremely extensive, a Weblog can begin to blur the line with online forums and bulletin boards.

Should your Weblog have this feature enabled? It's a matter of taste and time. The time aspect is that while the first comments to a new post are often interesting and insightful, the quality of the comments frequently declines as the post ages. Spam — as well as comments containing many of the seven words that George Carlin says you can't say on TV — eventually start to proliferate, and weeding them out can be a chore.

It's telling that three of the biggest blogs in the Blogosphere — InstaPundit, Power Line, and Hugh Hewitt's Weblog — all lack comments. When I asked Hewitt whether Weblogs should have comments enabled, he frowned upon them, adding, "I don't believe that bloggers have quite figured out yet the danger of the comments policy," especially from what he calls "black blog ops," or mischievous hackers willing to post disinformation on unsuspecting Weblogs' comments sections.

As Hewitt notes, "If it's your site, you're responsible for what's on there. The danger of defamation is real, as is copyright violation. That's why I don't have them — I just don't have the time to patrol and take down anything that could be defamatory, and if it's on my site, I'm liable." Of course, like all aspects of Weblogs, it's certainly possible to experiment with comments on and off, and see which you prefer.

Why Not Start Blogging Today?

Blogging is so easy to get started, and can be free, or extremely low-cost. It can be a great hobby in and of itself, or an enjoyable adjunct to an existing one. It's a great way to share your latest project with the world. Why not get started today?

Who knows — *Time Magazine* could eventually be calling! And even if they don't (which, truth be told, is more likely), you'll have an enormous amount of fun along the way. NV

Chasing the Long Tail

Perhaps the most significant theory that Hugh Hewitt discusses in his book called *Blog* is the concept of "the long tail," a term coined in the fall of 2004 by Chris Anderson, the editor of *Wired Magazine*, who, incidentally, now has his own Weblog, at **www.longtail.typepad.com**

While Anderson didn't initially create the concept specifically for Weblogs, the long tail has tremendous implications for anyone planning to blog. It's what the military calls "a force multiplier," and a way for someone whose blog might not have much traffic to generate a surprising amount of impact.

The most well known bloggers, such as those we've mentioned in this article, can receive hundreds of thousands of visitors a week, and the lion's share of attention from big media.

But as we said at the start of the article, the Blogosphere is composed of approximately seven million blogs. **Technorati.com** — the blog-oriented search engine — tracks over five million of them. Surveys show that less than 50,000 Weblogs are updated daily, but as Hewitt writes, that's "the sleeper fact" of these numbers. "From the big bang of blogging, 50,000 new virtual newspapers had been born."

The vast majority of those blogs go unnoticed by big media. But there's another factor to them that is little understood outside the Blogosphere — because they have smaller, but often more intense groups of readers, when they focus en masse on a story, they can generate amazing word of mouth.

Hewitt says, "I would rather have 90 percent of the blogs and none of those top ten percent bloggers writing about my book, than I would have all of the top ten percent and none of the 90 percent doing so.

Because the 90 percent of the tail operate in very high trust environments — they're read by their brother-in-law, they're read by their neighbors, their friends in church, their friends at work. If they say, 'hey you ought to read this book,' it'll sell a lot of books!"

Hewitt says that if a highly trafficked, household name site such as InstaPundit promotes *Blog*, he'll obviously sell lots of copies. "But the total traffic on the 90 percent of the tail is going to dwarf the total traffic on the ten percent, or even the one percent. That's the power of the tail. And what matters is how do you get the meme going in the tail."

This is a concept that the mainstream media simply doesn't understand. "They've never worried about the tail, ever. And now they've got the tail just eating them, all day, 24/7," Hewitt chortles.

THE FIELD EFFECT TRANSISTOR

A Necessary Device for the Modern IC

by Dan Shanefield

The commonly used bipolar transistor — in which electrons or holes pass through two PN semiconductor junctions — is essentially a current amplifying device. Although voltage can be amplified indirectly if the "common emitter" or "common collector" wiring configurations are used, it still is true that a small amount of input current must always flow into the transistor's base region for control purposes. (The reasons for these facts are explained in the book referred to at the end of this article.)

Another type of semiconductor device, the field effect transistor or "FET," is not as familiar to many electronics hobby enthusiasts, possibly because it is easily damaged by misuse. The FET amplifies voltage directly, and the current needed for control is so low that it cannot be measured with common instruments. This transistor was actually the first type of semiconductor amplifier predicted theoretically at Bell Labs, back in the 1950s, but it was not developed into a practical device until after the bipolar type had become popular. However, FETs have now become the most common type, with tens of millions of them in each microprocessor IC chip.

With such a huge number of transistors operating in a single chip, we certainly don't want much current to be required for the control of each one — the battery power would be used up fast, and a lot of heat would have to be removed. Also, there are many other applications where super-low input current is desirable. An obvious example is in the first stage of an accurate voltmeter, where we don't wish to cause any new voltage drops by draining current out of the circuit being studied.

Still another advantage of the FET, probably less important, is the fact that its input versus output characteristics are similar to those of vacuum tubes. Because tubes have been used since about 1910, we have a great deal of experience with them, and some designers feel more comfortable with FETs than with bipolar devices, especially in audio amplifiers. (Whether or not this is truly an advantage borders on emotional factors as much as scientific ones. Some readers might recognize the author of the present article as an early partisan on one side of this intensely debated issue, so we won't discuss it any further here!) At any rate, the FET responds entirely to voltage at the controlling electrode, and this can be used to throttle fairly large amounts of output

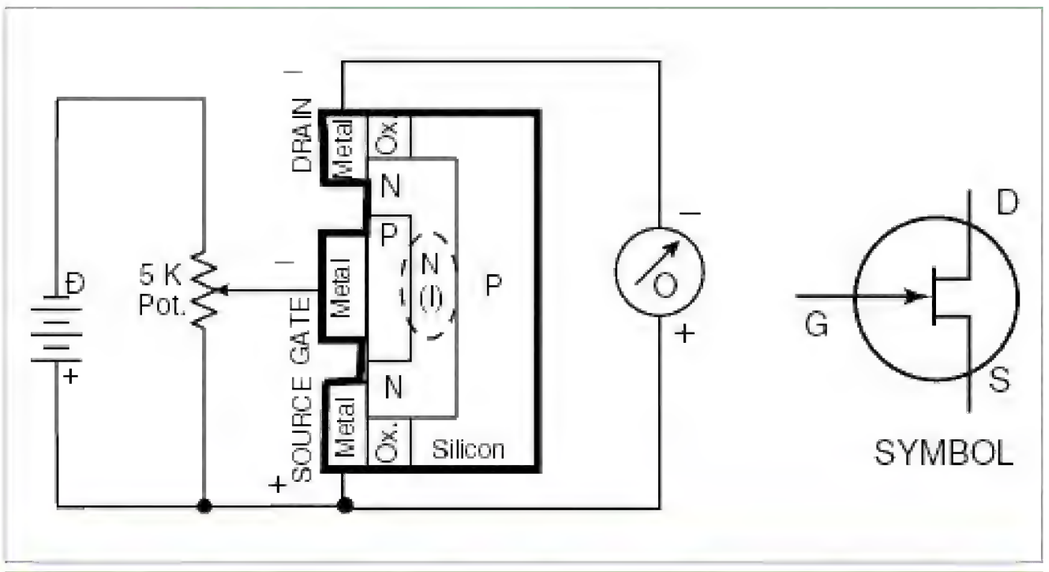


Figure 1. Simplified cross section of a JFET, with an operating circuit. It is N-channel, depletion mode, and normally on. The symbol is at the right-hand side of the figure.

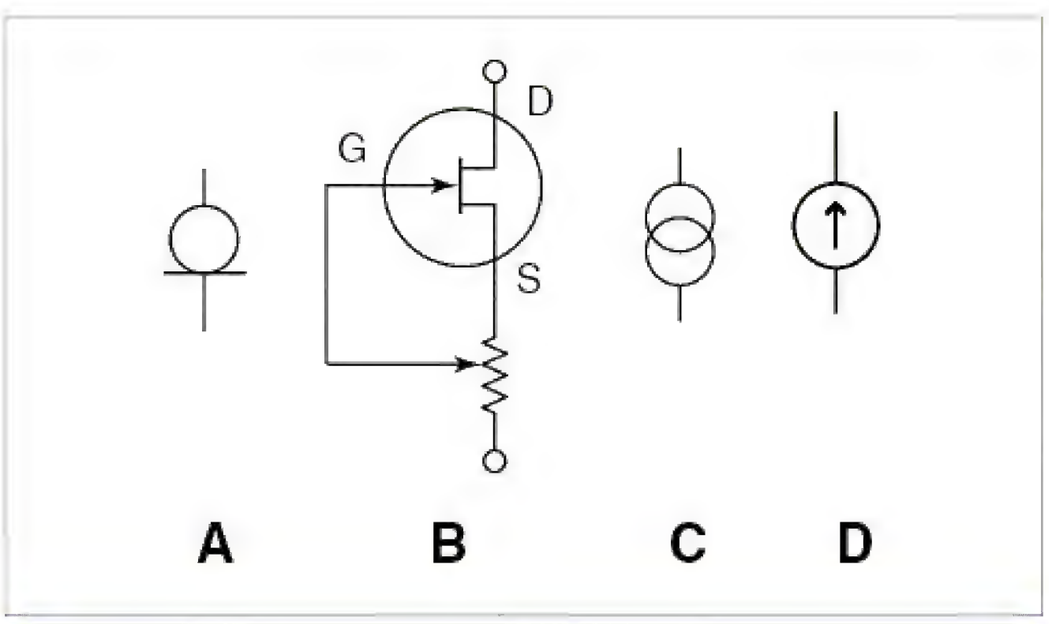


Figure 2. An N-channel JFET wired to be a constant current self-regulating device, with the symbol shown next to it on the left. The other two symbols, to the right, are for constant current sources that include power supplies such as batteries.

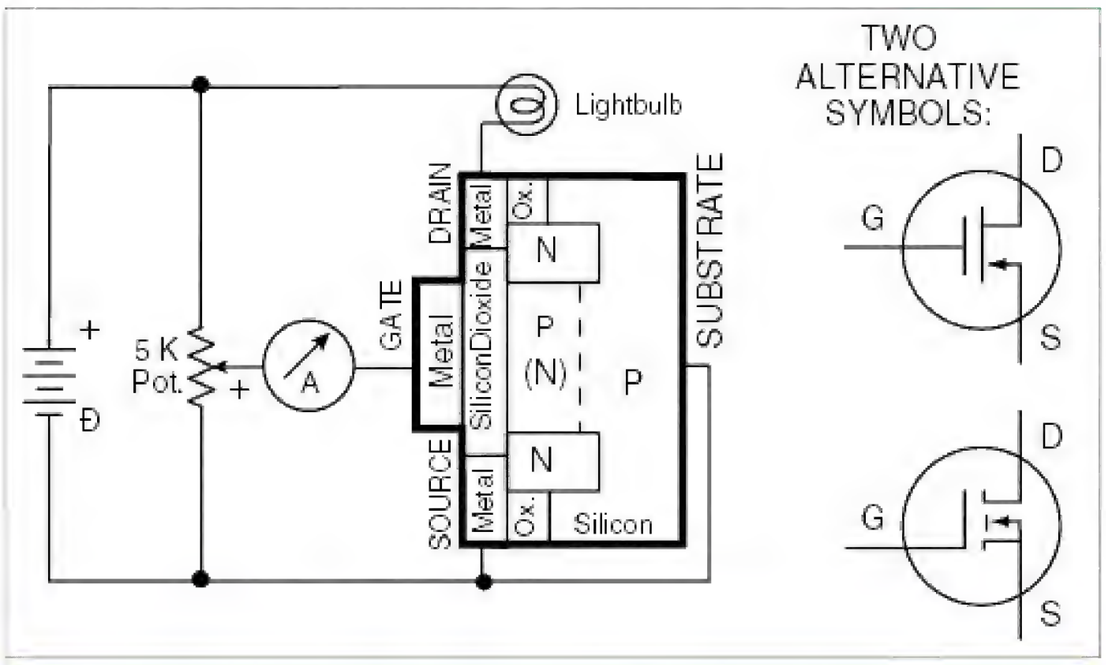


Figure 3. Simplified cross section diagram for a MOSFET, with an operating circuit. It is N-channel, enhancement mode, and normally off. Two alternative symbols are shown at the right.

current and/or voltage in the other two wires.

The JFET

Instead of making a transistor that conducts through both PN junctions when it is turned on ("bipolar"), one type of FET transistor can be made with just a single PN junction ("unijunction"). Since it does have a junction, it is called a juncFET or JFET, and a simplified cross section diagram is shown in Figure 1. The rectangles enclosed by a thick line are solid materials, including two regions that are P-type silicon but do not conduct appreciable current. There is an N-type region in the middle that can conduct all the current. In the very simple circuit shown in the diagram — which the reader can easily construct to get some experience with the JFET — an ohmmeter provides a voltage and also indicates a flow of load current. This type of FET is normally in the turned-on state, before any control voltage is applied. If the 5K potentiometer is set so there is no voltage on the "gate" (by sliding its arrow downwards as shown in the diagram), then "positive" load current from the ohmmeter goes into the upper left corner of the FET, then down into the topmost metal, then down through the continuous N-type silicon, and out of the transistor through the lower metal. (The "Ox." regions are silicon dioxide insulators.)

The diagram is not drawn to scale, and the rectangles show regions that are actually only about a micron in size. (A more formal size designation is "micrometer," which is a millionth of a meter.) The metal is usually a thin aluminum or copper film about a micron thick, and the whole configuration is sometimes more complex than shown in this simplified diagram. The P-type silicon (to the right, as drawn here) is mainly just a mechanical support for the smaller active regions that do the conducting. It is often referred to as the "substrate."

To turn off the transistor, the 5K pot setting can be raised to provide a negative control voltage. This charges the P-type region, but practically no electricity actually flows, because there is a "reverse-biased" PN junction (negative voltage on P-type silicon and positive on N). However, this charge strongly repels electrons from the very thin N-type conductive "channel" in the middle. A depletion zone conaining fewer electrons is formed there, so the silicon inside the dashed-line oval becomes intrinsic (I-type, as symbolized by the I in parenthesis), which is insulating, and the FET stops conducting. This type of behavior is called "depletion mode." Because the controlling action is done by an electric field (and not by carriers flowing into a base region), the whole device is called a field effect transistor, or "FET."

One metal electrode is called the source, one is the gate, and one is the drain, similar to the emitter, base, and collector in a bipolar transistor. This is an "N-channel" device, because the current goes through N-type silicon. The symbol is shown to the right of the cross section. Another type of JFET, a "P-channel" device, has the opposite types of P and N semiconductor regions, so the arrow in the symbol is aimed away from the channel. That type of gate must be charged positive in order to turn off the channel by repelling holes. It is not as common as the one shown here, but it does exist, and it can be useful for special purposes.

Constant Current Diode

An interesting application for the JFET is in the "constant current diode." The total effect of this is similar to that of a bipolar voltage regulator, except that current is regulated here instead of voltage. This can be a very simple circuit, as shown in Figure 2, diagram B. Looking at the negative current that flows upward through the resistor, some of it will be sent to the gate, which partially turns off the FET. This is negative feedback, so if the current in the circuit starts to increase, then the transistor gets turned off even more. Thus, less current flows, until some constant current level is reached. The JFET and potentiometer are all inside an insulating plastic "package." That whole thing, plus a power source like a battery (not shown here), is symbolized by two overlapping circles, Figure 2, diagram C. Occasionally an alternative symbol is used, with an upward arrow, especially in Europe, as shown in diagram D.

The MOSFET

A different kind of field effect transistor is illustrated in Figure 3, the metal-oxide-semiconductor or "MOS" device. In this transistor, there is insulating silicon dioxide to prevent gate current from going into the main semiconductor,

Parts List

JFET, N-channel
Potentiometer, 5,000 ohms
Power MOSFET, N-channel
Lamp bulb, tungsten, 12 volt, 40 mA
Battery, nine volts
Multimeter
Static-grounding wrist strap

Reference for Further Explanation

Industrial Electronics for Engineers, Chemists, and Technicians, by Daniel J. Shanefield, William Andrew Publishing, 2001.

instead of the reverse-biased junction that was used in the JFET. This one is sometimes called an "IGFET," because of the insulated gate. It is a normally off device, which has to be turned on by some sort of action, and therefore it is referred to as an "enhancement mode" device. (The IGFET can also be made in a depletion mode configuration.)

In the figure, if the pot is turned down to zero voltage, then the battery current tending to go through both the lightbulb and the transistor will be stopped by one of the PN junctions. In this diagram, it is the upper one, which is reverse-biased. (Initially, the dashed line and the N region in the middle are not present.)

If the potentiometer arrow is raised, and a positive potential is now applied to the gate, holes in the P-type silicon are repelled, causing this region to become N-type (as indicated by the N in parenthesis). Now there is no PN junction directly in the path between the upper and lower N-type regions, because it is all one continuous N-type region (drawn as a vertical bar, with the dashed-line as one edge). This transistor is also N-channel, because the electricity goes through N-type silicon when it is turned on.

If the reader wishes to get some experience with the MOSFET, an ammeter can be placed as in Figure 3, to show that no measurable current flows into the gate, even when the bulb is lit. In this diagram, the multimeter has been switched to measure current, and it is moved to the gate lead. (This cir-

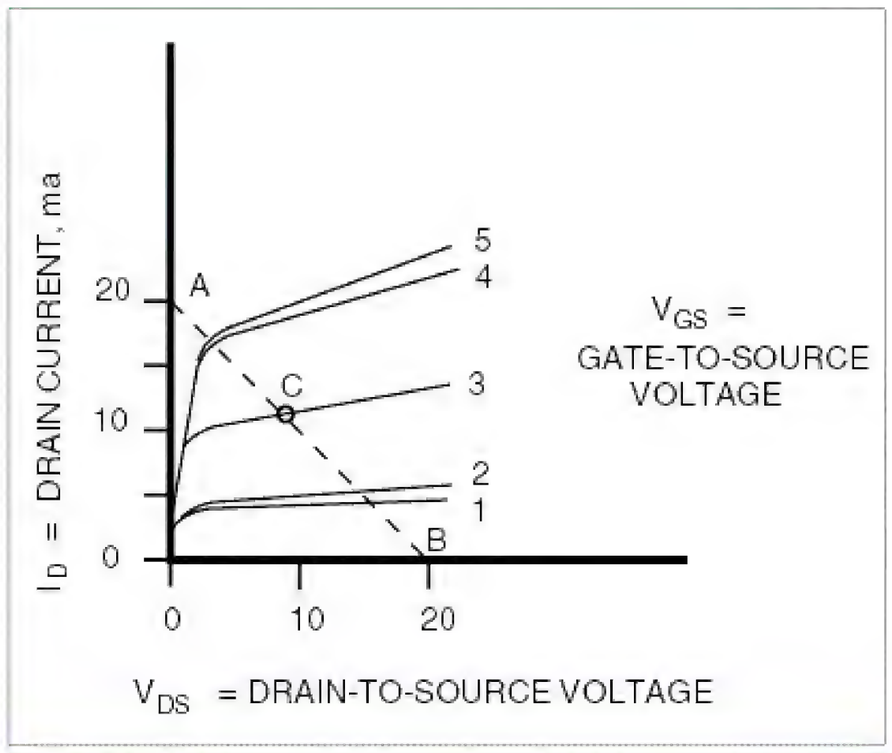


Figure 4. Characteristic curves for a 2N7000 MOSFET, with a load line.

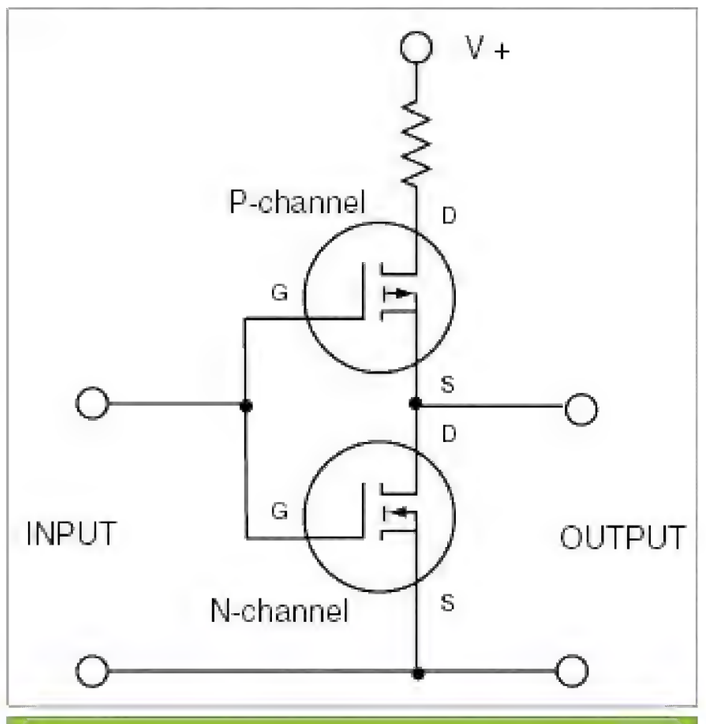


Figure 5. CMOS transistor pair. The current is extremely low when there is no input signal.

THE FIELD EFFECT TRANSISTOR

cuit could be used for the JFET experiment also. The experimenter should note that precautions for avoiding damage to MOS devices are described in the ESD Sensitivity section below.)

Symbols for the MOSFET are shown on the right. The arrow, in this case, indicates that the "source" electrode is internally connected to the substrate, which is often done if one of the PN junctions is not going to be used.

If the device were P-channel, the source and drain would be P-type, and the arrow would be aimed away from an N-type substrate.

Characteristic Curves and Load Line

Typical FET "spec sheets" use formats similar to those of vacuum tubes. The shapes of the curves are almost the same, but the voltages are usually much lower. The input is the VGS and the output is the ID. In this case, a type 2N7000 MOSFET is used in N-channel enhancement mode.

A "load line" is shown here as a dashed line. Its slope represents the effect of a load resistance (such as the lightbulb in Figure 4), and it is quite valuable as a way to show the amount of current in any situation. In the case graphed here, the load resistance is 1,000 ohms, and VDS is 20 volts. The dashed load line is drawn from the maximum possible voltage (shown here as B) to the maximum possible current with that particular load, which is 20V/1KW = 20 mA (shown as A). If the transistor is turned partly "on" (VGS = 3 volts), the drain current would be about 11 mA, as shown by the intersection (the circle under the letter C).

CMOS

Two MOS transistors of opposite type can be wired as in Figure 5, in the complementary MOS configuration ("CMOS"). When no signal is fed to the input, one of the transistors is always "off," so essentially zero current can get from the power supply down through the resistor, and then through the pair of transistors. When a signal comes to the input, then load current can be drawn from the output terminal, at either high (V+) or low (ground) voltage, depending on the polarity of the input voltage. However, in the situations when there is no input, the overall current is practically zero.

Modern integrated circuits have millions of transistors attached in parallel, so if only a microamp of "leakage current" flowed through each one that was not being used, an ampere or more would still be drawn from the power supply or battery at all times. That would generate a lot of heat and also drain batteries too fast for portable devices. Therefore, almost all modern calculators, laptop computers, cellular phones, etc., use CMOS circuits whenever possible.

ESD Sensitivity

The MOS transistor is particularly susceptible to damage from static electricity, of the kind generated when a person walks across a rug in dry weather. The spark that the person makes when touching the metal faceplate on a light switch is called electrostatic discharge, or "ESD," but damage can be done to a MOSFET, even if there is not enough static to make a visible spark.

Static electricity can destroy the very thin silicon oxide that insulates the gate. Some MOS transistors are protected by zener diodes that are attached in parallel with them, inside the packages, but most are not protected. To prevent damage, people handling IGFETs should always follow these two precautions: **1.** Only touch the plastic insulation with your hands, not the metal leadwires directly; **2.** Use a grounded wrist strap. The latter is a plastic band (usually black or pink) that conducts electricity and is attached to a long wire. It should be fastened around either wrist, touching the person's skin, and then the other end of the wire is hooked up to a good ground connection such as a water pipe. **NV**

About the Author

Dan Shanefield is a retired Bell Labs scientist and Professor. You can visit his website at ***http://homepage.mac.com/shanefield/Resume1.html***

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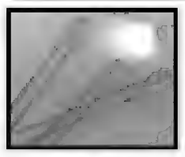
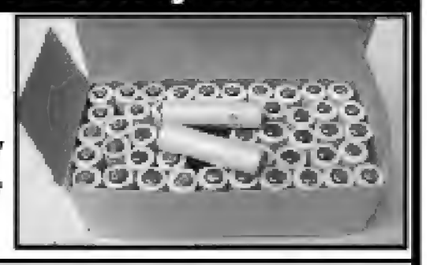
White LEDs *Amazing BRIGHT !*



Get a load of this incredible price on super bright WHITE LEDs! Minimum 4,500 mcd AMAZINGLY BRIGHT! 3.4 volt 20 ma. We bought out the entire factory! Stock up now at these incredible prices! All factory prime material!

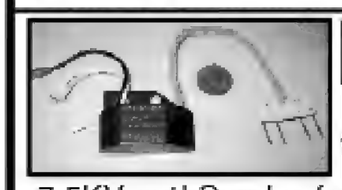
0135037R	50 pcs	$19.95
0135037	500 pcs	$99.95

Rechargeable Battery Blowout!



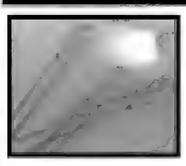
Big box of 50 brand new AA but ton top NiCads. Fit anywhere an AA battery does. 1.25V 800mah. Best price in the USA!
0128870R $19.95

Ion Generator



Its super easy to build your own Ion Breeze air purifier! New module, 120 VAC in, 7.5KV out! Surplus from air cleaner maker who sold them for $200! 0128873R $7.95

Windsor's Blue LED Special



Holy Smokes! Can you believe the price on this BLUE LEDs? First quality from our factory buyout. Big and bright! These normally sell for $1.50 each and that's in big quanti ties! We're crazy to sell 'em so cheap!!

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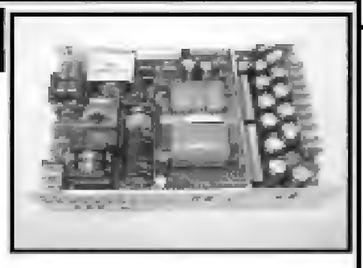
0131297	500pcs	$99.95

Nicad Battery Pack

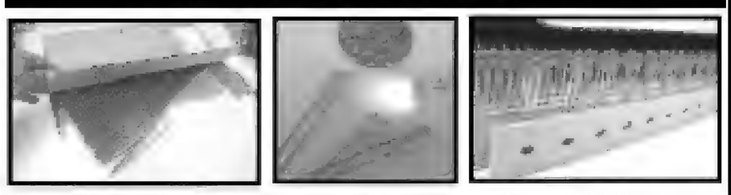
Brand new high power density rechargable bat tery pack. 6 volts, 650 maHr. Space saving rec tangular shape approx 2x1x0.75" 6" wire leads.
0132161R $4.95

Power Supply



Nice new switching supply. 100 240VAC IN, OUT: +5V@20A, +12V@6A, 12V@1A, 5V@1A. Screw terminals, size 6.2"x4"x1.4"
0133539R $14.95

LED BLOWOUT !!!



Here's a deal that just will not last long Wind sor's LED Blowout! Super high quality, factory prime bright LEDs. Ideal for all those projects that you've wanted to build, but just didn't have the quantity of LEDs needed. You will not find pricing like this ever again we bought out two factory inventories! Here's the scoop: Big bag o leds have 500 pcs and are all RED jumbo 5 mm size with crystal clear bulbs. You pick the lumi nous intensity, bear in mind that the 2500 mcd high bright units are flashlight intense! Big buy ers will love the 2,000 LED boxes! These LEDs are the smaller T 1 size with full leads, available in Red or Green. Imagine 2,000 Leds for less than a penny each!

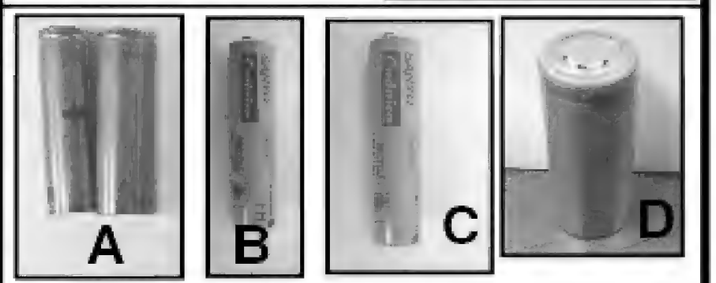
0131288R High Bright	500pc bag	$19.95
0131292R Standard Bright	500 pc bag	$14.95
0130956R Box o leds Red	2,000pcs	$19.95
0130955R Box o leds Green	2,000pcs	$19.95

Nicad Battery Stick

Brand New 4.8 V 500 maH 0133511R.....$4.00

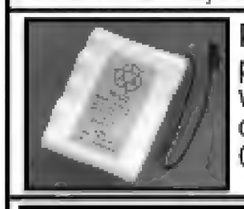
Piezoelectric Alarm

WOW, is this thing LOUD! Runs on 2 12 VDC and draws mere milliamps, 103db output! Rotat ing bezel allow easy volume con trol too! 1.25" dia and 1.5" long. Google for specs: Bell Audiolarm XC V09 212 S
0132165R $4.95



Popular Nicad batteries, 1.25V All brand new. Battery in picture A has no sleeve.

A: AAA 400mah	0125339R	2 for $1.00
B: AAA 250 mah	0133089R	5 for $3.00
C: AA 700mah	0132163R	5 for $3.00
D: 2"x.75" 2,000mah	0135426R	5 for $6.00

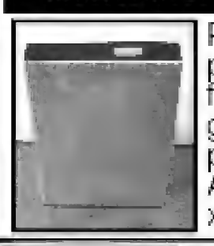


Prime, new 5 AA cell nicad pack. 6 Volt 700mah with 6" wire leads. Great for projects, cordless phone replacements.
0125345R..... $2.50

Electroluminescent Light Panel

Electroluminescent light panel as used in LCD backlights, runs on 75 140 VAC. Soft green glow, ideal for nite lights or fancy light ing projects, runs great on regu lar AC line voltage. Size 2.75" x 1.25" and just a few hairs thick! Super neat great project item!!
0133512R Bag of 25 pcs!.....$5.95

Lithium Ion Rechargeable !!



Rechargeable Lithium batteries pack the highest density of power for size and weight! Ideal rectan gular size is easy to fit in your project. 3.6 Volt and approx 0.8 Amp Hour capacity. Size 1.75" x1.2x.22" 0135427R $2.50

CCFL Florescent Light Inverter

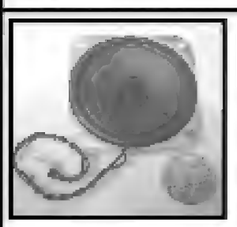
New power inverter drives 2 lamps up to 5W each! Simple to use, 12 VDC in, con nect florescent lamps to output. Module gen erates correct starting and operating voltage, lamp current and is even dimmable! Works great with the EL panels above (0133512R)!
0128520R $9.95

C size Nicad Battery

This is the real deal, a true 2 A Hr Nicad, Button top works in any device too! Brand new by Sanyo.
0130380R $2.00

Laser Fiber Optic Transmitter

Brand new HP Agilent model LST2829 Laser transmitter mod ule. Capable of 622 MB/s data rates, 1 mW output power, 1300 nm wavelength, includes on chip power monitor diode. These are high end quality lasers and not often found on the surplus mar ket! Two style available, A: 32" long thin pigtail fiber and B: 16" long encased fiber. Each has the same electrical specs. Price: $9.95 each
Item A: 0128526R Item B: 0128536R



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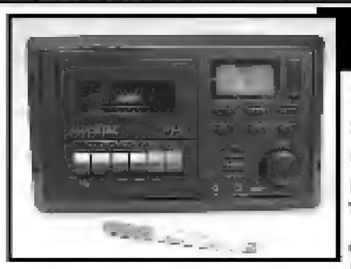
0133529R..... 3 for $4.95

Truck Stereo



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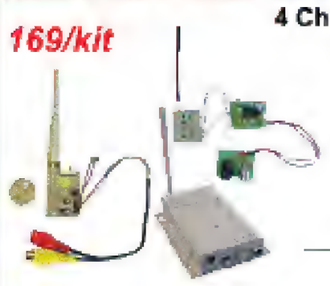

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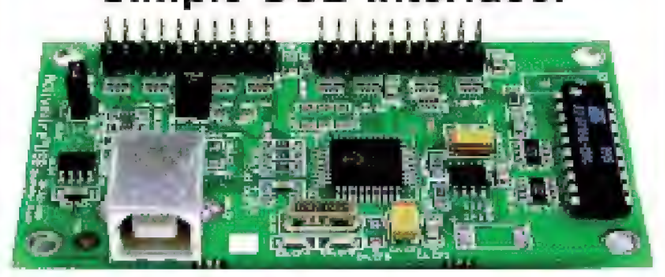

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Continued from Page 6

Reader Feedback

Dear Nuts & Volts:

Generally, you have a fine publication, well written, carefully planned, and thoughtfully layed out and, while it was with great regret that I was witness to the demise of the Gernsback publication *Poptronics*, it was worth losing it to discover *Nuts & Volts*. Where have you been all my life?

Well, enough gushing. All that said, I discover you are subject to some of the same problems that likely plague all technical publications — having to rely upon contributing authors to supply accurate data/information with their submissions. I refer to the strobe light project "In the Blink of an Eye" in the May 2005 issue. The author, Andy Sullivan, presents erroneous data points for the charging of an RC circuit. He states that an RC circuit will charge to 40% of full charge in one time constant (TC), 75% in two TCs, 90% in three TCs, and 96% in four TCs. These percentages, as well as his assertion that a capacitor is fully charged after four TCs, are incorrect. If these percentages are derived from empirical measurements, Mr. Sullivan must have some extremely leaky capacitors.

The true data points for charging capacitors/RC circuits are:

1 TC = 63.7%
2 TC = 86.8%
3 TC = 95.2%
4 TC = 98.3%
5 TC = 99.3%

The charge percentages are derived from the fact that each time constant actually charges the same percentage as the previous TC: 63.7%. However, each TC can charge only 63.7% of the **differential voltage** between the capacitor and the source voltage. Example: In the circuit in question, the source voltage is 340V.

TC	V cap.	V charged
1	216.6V	216.6V
2	295.3V	78.5V
3	323.8V	10.3V
4	334.1V	3.8V
5	337.8V	1.4V

V diff. remaining	% full charge
123.4V	63.7%
43.9V	86.8%
16.2V	95.2%
5.9V	98.3%
2.2V	99.3%

After five TCs, the differential voltage becomes so small as to be inconsequential, and the amounts of capacitance and/or duration of time constant are irrelevant to the percentage of full charge per time constant.

I hope this has been helpful in clarifying the RC charge cycle.

Charles Rhines
Sioux Falls, SD

Response: *Thank you for taking the time to read my submission, "In the Blink of an Eye," and for submitting a response. You raise an interesting point about charging RC circuits. The percent of charge as a function of time is different if you are talking energy or voltage. Because the strobe circuit was sized to provide the appropriate energy to the strobe tube, my numbers indicate the percentage of total energy charged in an RC time constant. Total energy is represented as follows, where U is the percentage of energy when fully charged:*

$$U \approx (1 - e^{-t/RC})^2$$

Your values represent the percentage of total voltage built during charging. The energy charged is proportional to the voltage squared, as shown below where C is the capacitance:

$$U = \frac{1}{2}CV^2$$

Squaring your values for voltage yields my values for energy as shown below. U = % energy charged and V = % voltage charged.

t/RC	U	V
1	0.400	0.632
2	0.748	0.865
3	0.903	0.950
4	0.964	0.982
5	0.987	0.993

— Andy Sullivan

The Business of Electronics Through Practical Design and Lessons Learned

In The Trenches

Managing Engineers

This article is going to be somewhat different from the past ones. Instead of addressing a topic that is directly applicable to engineers, I will look an important indirect topic.

This is the management of engineers by someone who does not have a technical background. It is often the case that management-trained people are asked to direct a technical group. But, without an understanding of the needs and expectations of engineers, the non-technical manager can be at risk from considerable culture shock.

The Engineering Profile

As a group, engineers are different from most other groups. (Please note that this is a general discussion. Individual engineers vary a great deal.) Engineers take an idea and make it real. Artists and musicians do the same except that engineers create practical devices. This means that engineers are both creative and pragmatic.

This is a very unusual combination of traits. It is also a powerful combination. Just look around. Virtually everything you see was designed and realized by an engineer. Your chair was designed by an engineer. Your clothing was made by machines designed by engineers.

Your computer ... the floor tiles ... the light fixtures.

It's natural for people of similar traits to be drawn to certain jobs. It's very important to understand this. Engineers like (perhaps love is a better word) their profession. (Please note that profession and job are not the same.) They like making things. They like solving problems. What's more, engineers often take their profession home.

Many engineers have a personal lab. Many engineers made a hobby of "engineering" while in high school.

Quite simply, engineering is a way of life. Obviously, this is very different from administrators and managers. Few of these people go home and read a "Modern Management" magazine for fun or practice with new ways of writing budget reports.

Engineers are generally honest and straightforward, often to the point of being blunt. Subtlety is not something they recognize well. But they *have* to be this way. If their design fails, there is no one to blame except themselves because their signature is on the drawings. It is also an inescapable fact that you can't fool Mother Nature. You can fool yourself and others, but the laws of physics prove the truth of any design.

This honesty requirement manifests itself in two very important personal aspects. The first is responsibility. Engineers rarely try to deny responsibility for failure. This is quite unusual. Few others are willing to do this. How many times have you seen finger-pointing and excuses? Have you ever heard an administrator say "That's my fault. I screwed up."?

Engineers do this because, as noted above, their name is on the drawings. At the most, they'll say "It wasn't designed for that." Or, "It wasn't in the specifications." The fact that they are able to admit mistakes indicates a large ego and strength of character. These are important traits in themselves but are often overlooked because engineers are generally somewhat non-social. They do not exercise these traits for social authority as others might do. But, simply because some things are not obvious doesn't mean that they aren't there.

The second aspect is that they expect to see honesty from others. Within the engineering community, this is a reasonable expectation. However, in a social or business setting, it can be somewhat naive. It's important to understand this. Don't put them in a situation where it can be detrimental. And never, never lie to an engineer. If an engineer catches you in a lie, he will never (yes never) trust

you or respect you again. (If trust and respect are not important to you, you have other issues to address.) Deliberate, misleading statements are taken as lies as are unkept promises. If situations force you to renege, explain it in detail.

Management Style

Once you understand the basic profile of the typical engineer, it is obvious that the "Y" style of management is the most appropriate. (The "Y" theory says that people like to work.)

All you have to do is provide the necessary tools, create reasonable deadlines and objectives, insulate them from departmental politics and paperwork, and watch them take off. Remember, they like their profession. The last thing you want to do is make them dislike their job. Unfortunately, this happens with a fair degree of regularity. There are many reasons for this.

Some managers are intimidated by the education and intelligence of personnel in their department. They mistakenly think that constantly exercising their authority will cause the engineers to respect them.

They fear losing control. Engineers recognize teamwork and the need for direction. But ongoing interruptions, micro-management "suggestions," meetings, and reviews only serve to antagonize engineers.

Other managers take the position that since they are, after all, senior to the staff, they must be better, as well. The idea that the manager always knows what's best is simply wrong.

While it is true that the manager is responsible for the department, it is foolish to think that the manager is the best one for making technical decisions. If the manager was technically oriented, he'd be an engineer, rather than a manager.

Additionally, the concept of the manager being the departmental "father-figure" is silly. Following this faulty logic suggests that one gets smarter as one manages more and more people.

If this was truly the case, then every world leader should be a genius and they should be able to solve every problem themselves (including curing cancer, predicting earthquakes, and controlling the rat population in cities).

A proper analogy is a sports team. The manager is the coach of the players. The coach cannot be intimidated by the skills of the

players. Nor is the coach expected to play on the field. A good coach shapes the team to make the best use of the individual strengths of the players. Athletes — like engineers — want to perform to their best.

Management Suggestions

First and foremost, listen to what your engineers say. In all probability, they are smarter than you. They are certainly able to appreciate the technical situation better. If they are not considering some political or administrative factor, tell them so. Give them the opportunity to consider it and respond. There's a good chance that they can provide a usable compromise solution. Don't simply dismiss them with, "You don't understand the situation." Take the time to make them understand. That's part of your job (making your personnel more effective).

Engineers dislike meetings and consider them a waste of valuable time. Most often, they're right. Consider this: a one-hour meeting with eight engineers consumes one man-day of engineering time.

On the other hand, suppose you walked around to each engineer and got a personal progress report. At five minutes per engineer, that's less than one man-hour of engineering time. You increase efficiency, make your engineers happy, and gain their respect. What's wrong with that? It still takes you an hour with either method. So, unless there is a real need for a meeting, don't call one.

Allow the engineers to solve resource allocation (or other departmental problems) by themselves. It often happens that some major piece of equipment is needed by multiple people. If you set the rules, you will be required to settle each and every dispute about equipment use, forever. Is this what you really want?

Instead say something like, "I expect you to be able to share the machine. And I will not take your inability to get machine time as an excuse for being late. If you can't share, I'll set an arbitrary schedule nobody will like." A little psychology can go a long way.

Critical Details

I often say that engineering is common sense with attention to detail. With the most important thing being the details. This is because the details are absolutely critical to the success of the design. Countless catastrophic events have

been traced to improper detail consideration.

A ground water leak into a tank started the Bophol disaster. Falling foam destroyed the Columbia space shuttle. Wind loading was neglected in the Tacoma Narrows bridge. And on and on and on. It cannot be overstated that details determine the fate of any engineering endeavor.

This means that you should never make an engineering change without — at the very least — verifying it with the engineer. And if the engineer objects, listen. The sad fact is that unilateral administrative engineering changes happen all too often. Here's a classic example.

In the late 1960s, a new rifle was being designed for the American military. It was called the M-16. The prototypes worked very well and the rifle was sent into production.

At this point, very senior civilian government people, who had no experience in engineering or small arms, decided that chrome plating the receiver (the place where the cartridge rests during firing) was too expensive. The bureaucratic managers changed this tiny detail. No chrome plating was to be used.

The result was that the non-plated receiver pitted and corroded from the gasses of the gunpowder. This caused jams and misfires. Worse, these jams required the whole rifle to be disassembled to remove the jammed cartridge.

Naturally, this is not a desirable thing to happen while under fire in the jungles in Vietnam. Many American soldiers died and the M-16 got a bad reputation until this detail was "fixed" by chrome plating the receiver.

More recently, the space shuttle Challenger failed because administrators decided to launch in cold weather in spite of the objections of the engineers. Simply having the authority to decide does not make you decide well.

Engineering Code Phrases

There are a number of special code phrases that engineers use that mean something different than the actual words. Different companies and organizations may have different ones. It's important to learn and understand them.

For example, suppose you ask an engineer about designing a product with a certain set of specifications. He may respond with something like, "Obtaining a proper frequency response is not trivial." "Not Trivial" is a code phrase. It sounds innocuous but it really means

"nearly impossible." The specifications requested may have been obtained before, but only under special conditions.

So, incorporating them in a mass-produced product will take significant effort. But it's probably possible.

Suppose he answers with "Obtaining a proper frequency response is difficult." This means that "I don't know how to do that and I don't know anyone who has. But, like flying a man to Mars, it should be theoretically possible." Solving such a problem will take considerable research and development, as well as time and money. And even then, the results may not be practical.

As you can see, engineers have a hard time saying something can't be done. So, when they actually say so, believe them. There is the old engineering saying that stands the test of time: "You can have it fast, cheap, or good. Pick any two."

Half-life

It's generally considered that the half-life of any engineering specialty is about five years. This means that about half of the information in that specialty is obsolete in five years. This is by far the fastest changing profession that there is.

This means that a five-year old textbook contains only 50% useful information. A 10 year old textbook has only 25%.

So, in order for an engineer to stay on top of his profession, he has to constantly learn new things. Good engineers understand this and strive to maintain their level of expertise. It's also important for you to recognize and foster their efforts.

It doesn't really take too much time or money to facilitate engineers' learning. Encourage them to go to manufacturer's seminars. These aren't very expensive — usually under $100.00 — and take about a day. But they provide valuable new information about new products and techniques.

Additionally, they help the engineer network with other engineers. This cross-pollination is useful in generating new ideas and solving problems.

Some managers fear this. They're afraid that if their engineers see what other people are doing, they won't be satisfied with their current job and leave. This is a silly attitude to take. Restricting the engineers' learning is very short-sighted. You are hobbling your engineer. Keeping them ignorant may make you feel powerful, but it makes your department less effective. The investment in learning is always

cost-effective.

Here are a couple of other good methods of encouraging engineers to develop. The easiest one is to contact a local distributor and ask them if a company would like to present a mini-seminar (an hour or so) on whatever new product they have.

Nearly every company would leap at the chance to promote their new product directly to a group of engineers. You could make it a monthly event (or more often, if you'd like). You could have it during lunch and provide pizza or something to munch on.

Manufacturers also provide evaluation kits at low cost. These kits provide hands-on experience with new products and technology. Let it be known that you encourage this. Provide space and time for the engineer to experiment. The result can be the development of state-of-the-art specialists.

Remember that engineers like learning and will do so on their own if given the opportunity. So give them that opportunity. (It should also be noted that the engineers that participate are generally the better engineers.)

But, some argue, you're making the engineer more valuable and they will leave for a higher paying job. So you are hurting yourself. Like all myths, this has a kernel of truth. If you are treating and paying your people poorly, they will indeed leave.

However, remember that engineers love their profession. If they also love their job, they won't leave. Just the opposite, they will enjoy their work.

It doesn't take a psychologist to know that people who like their work do a better job. So, by providing what the engineer needs to excel, you are actually binding them more tightly to the company. Fundamentally, people change jobs because they are not satisfied with their current employment, and therefore, aren't happy. If they're happy, they stay.

The short half-life of engineering information seems to imply that older engineers are no longer competitive. And for some, this is true.

However, as we have just seen, engineers like to learn. If they have maintained their education, then the older engineers are just as technically effective as the younger ones.

Additionally, life experience can provide them with better talents that take time to master. Troubleshooting, marketing, finance, and social skills often age well. These people tend to have very well-rounded capabilities. Having older engineers as mentors for younger

ones is very valuable.

Ex-engineers as Managers

Often an engineer will be promoted to manage an engineering department. This has its good and bad points.

Naturally, this manager understands engineers well and can initially provide useful technical advice. However, learning proper management skills can be problematical. Budgets, schedules, personnel interaction, management style — these can all take quite some time to develop.

But since engineers like to learn, most can make the transformation to management successfully. There is, however, one large latent problem.

This is that the manager/engineer often still feels that he is an engineer. As we've seen, the half-life of five years means that after 10 years, the manager possesses little useful engineering information. There are two basic reasons for this.

The first, obviously, is that the manager no longer works as an engineer.

The second is that few managers will expend the energy needed to maintain their engineering expertise. This requires considerable time and effort outside of their current job. So, most often, their engineering knowledge and experience languish.

The problem is that they are out of step with the current engineering techniques but they still feel that they are engineers. So, they often try to solve technical problems (something the engineering personality likes to do).

Unfortunately, they no longer possess the tools needed to provide appropriate solutions. This lack of self-awareness is the root of the problem. This results in "solutions" that are non-optimum or simply bad.

For example, one ex-engineer wrote a design proposal for a complex, real-time data gathering and analysis computer network. He specified that the software be written in Basic. He also designed all eight of the hardware inputs as interrupt driven.

Because he felt that he was still an engineer, he thought he could single-handedly create a great product without input from anyone else. He was wrong.

The design was accepted and delivered. And his engineers managed to develop workable software. However, the product would have been much better and cheaper if he had input from those with the proper expertise from the beginning. (Every engineer can provide similar examples.)

The point of this example is not to disparage the manager. Rather it shows the necessity for teamwork at all levels. Engineers, for the most part, tend to be solitary people. But the exengineering/manager does not have that luxury. He must always involve the appropriate people in design proposals and he must listen to what they say. It is critical that the ex-engineering/manager accept that he is no longer an engineer but a manager.

Admittedly, this is a hard thing to do. But that's why they pay you the big bucks.

Conclusion

Engineers are different. Even they will admit that. This causes a conflict of cultures between management and the engineers. If you can recognize this conflict, you will be able to deal with it.

And, in the process, you will develop better respect, understanding, and working relations with everyone involved. If you are a more effective manager, then your department will be more effective, as well. And for engineers, we know that being effective is something they want, too. **NV**

Approaching the Final Frontier

Near Space

BalloonSats

The BalloonSat program is an effort by the Space Grants of several states to capture the interest and imagination of college — and in some cases — high school students through a space flight experience. BalloonSats are miniature near spacecraft. They are limited in weight and carry only a simple data logger, sensors, and small camera. Students can quickly construct and test BalloonSats. BalloonSats carry no tracking equipment, therefore, they're carried as cargo on an amateur near spacecraft.

The Construction of a BalloonSat

The Colorado Space Grant has created a book explaining the BalloonSat program. The book provides the necessary information for students to create and test a BalloonSat without actually giving them step-by-step directions. BalloonSats are designed to meet a list of criteria. These can vary, but the criteria specified by the Colorado Space Grant includes:

1. Total maximum weight of 500 grams (1.1 pounds).

2. Maximum volume of 1,000 cm^3 (roughly, a four inch cube).

3. Temperatures must be recorded both inside and outside the BalloonSat for the entire mission.

4. Must carry one additional science payload (usually a small camera).

5. Built within a budget of $400.00.

6. Contact information recorded on the exterior of the BalloonSat (in case a farmer finds it first).

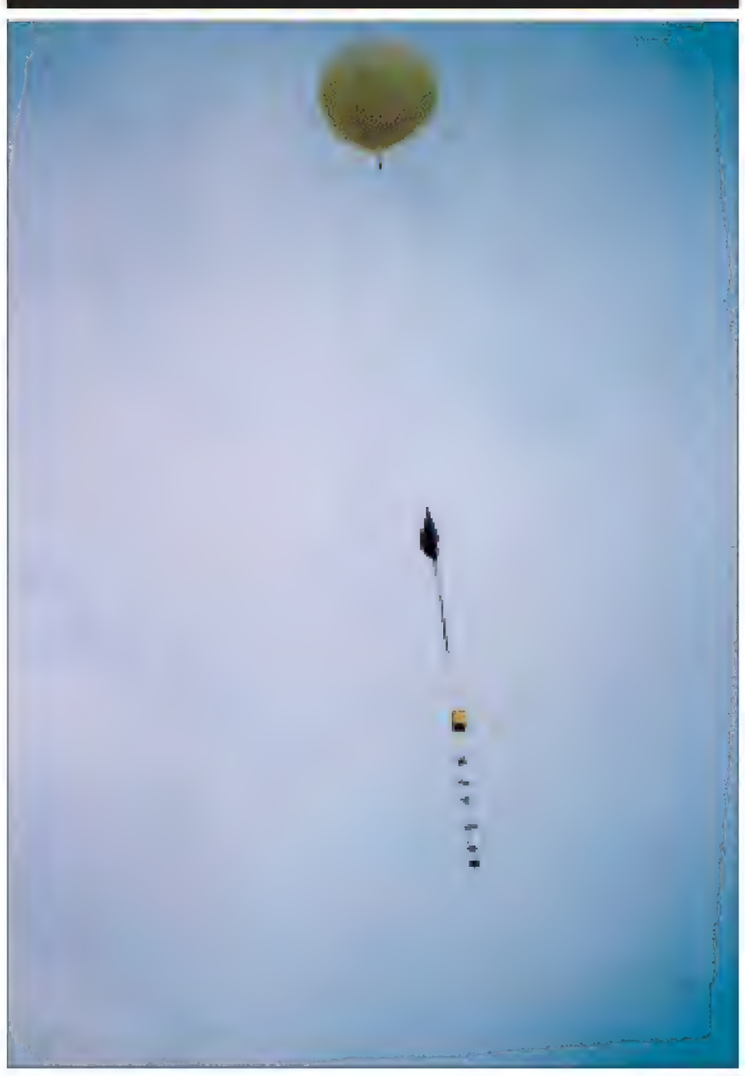
7. Successfully complete all preflight tests before launch.

Most BalloonSats I've seen are simple cubes with one opened face. The typical BalloonSat airframe is made from glued sheets of foamcore. Foamcore is a paper-backed 3/16 inch thick layer of Styrofoam and is available at art and framing stores. Space Grants recommend using silicone glue, JB Weld, or hot glue to assemble the airframe of a BalloonSat. The hatch covering the BalloonSat's opened face is sealed shortly before launch with tape or Velcro. The exterior of a BalloonSat is usually covered in aluminum duct tape.

A metal or plastic tube is glued through the center of each BalloonSat so it can be tethered to a near spacecraft. The tube insures that the flight string passing through the BalloonSat doesn't cut its way through the Styrofoam of the airframe. Several BalloonSats are attached to a single nylon flight string which hangs from the bottom of the last module of the near spacecraft. Knots tied in the flight string allow split rings to hold the BalloonSats in place. There's about a one foot separation between BalloonSats on the flight string.

The data logger inside the BalloonSat is an OnSet Hobo data logger. Students spend part of their

Figure 1. A gang of BalloonSats on their way to near space.



Logo for the Amateur Radio High Altitude Ballooning Community

At school, I have access to software I could never afford on my own. So when I learned about Corel Draw, I decided to give it a whirl with a logo for my favorite hobby. After lots of time and help, I came up with this design that I would like to share. I created the design partly because, while individual groups have their own logo, there isn't a logo for the hobby as a whole.

Please feel free to use this design in your own near space projects. The design is in the public domain and free to everyone. You can download it from the *Nuts & Volts* website at **www.nutvolts.com**

Figure 2. I spent two hours hiking up this snowy mountain to get the mission back. In places, the snow was five feet deep.

time learning how to launch (program) and readout data from the Hobo. The Hobos used in a BalloonSat have an internal temperature sensor, so to measure the external temperature, students use either a temperature sensor from OnSet or make their own (see my column in the August 2004 issue of *Nuts & Volts*, page 84).

A popular device carried onboard the BalloonSat is the Canon Elph APS Camera. The Elph camera is reasonably inexpensive and easily modified for use with an automatic timer (consisting of a simple 555 timer circuit and transistor switch). The camera may have already been modified when students get it, but that still leaves construction and adjustment of the camera's 555 timer circuit for them to do. My November 2004 (page 94) and March 2005 (page 80) columns have information on modifying cameras for near space use.

After constructing their BalloonSat, the team must evaluate the performance of their BalloonSat with a series of four tests. First is the weight test. Each fully loaded BalloonSat (this includes film and batteries) is weighed. The Colorado Space Grant BalloonSats can weigh no more than 500 grams and Idaho high school students are limited to 400 grams.

The functional test is next. Each BalloonSat must remain attached to the flight string (and not cut it) without suffering damage under normal flight conditions. Each BalloonSat must also show that it will collect data for the expected flight time.

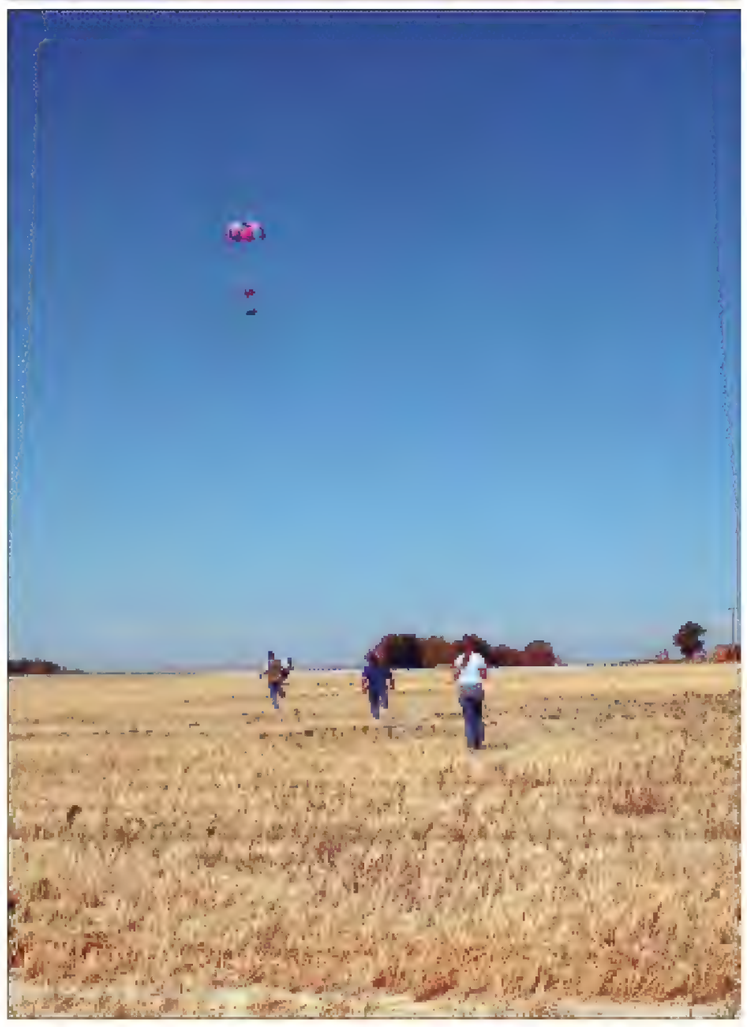
The third test is my favorite. The BalloonSat must function under the cold conditions expected during the flight. Each BalloonSat is placed inside a thermal chamber loaded with dry ice where it must record data for 20 minutes. The final test is the drop test. Here, each BalloonSat must survive a ground impact at speeds expected during recovery. The BalloonSat is dropped from a specified height and must remain in one piece and continue functioning.

If the BalloonSat passes these tests, the team calls it a day and gets some sleep. In the morning, the BalloonSat team meets at the launch site where an amateur near space group has agreed to carry their BalloonSat into near space. Remember, the BalloonSat doesn't carry tracking equipment, so the BalloonSat must piggyback with a near spacecraft.

Some of My BalloonSat Flights

Figure 3. BalloonSats.

Figure 4. I'm the one in the front left, hauling like crazy to catch my near spacecraft before it lands.



Often, the BalloonSat team accompanies the near space crew on the chase and recovery. However, they may not be prepared for the task of actually hiking out to get their stuff back!

On my last BalloonSat mission, I helped Idaho State University launch four BalloonSats. We ran into a slight problem on this flight. We sent four BalloonSats up but only one came back. The metal tube in the top BalloonSat abraded the flight line that carried all of the BalloonSats. Eventually, the metal tube cut the flight line and three BalloonSats below dropped off. Fortunately, a farmer found the three in his field and sent them back. On a positive note, I got my closest to catching a descending near spacecraft on this flight. I missed grabbing my

near spacecraft by only one yard (darn plowed field).

After watching BalloonSats get designed and helping to launch them, I have come up with some improvements. To back my claim, I ran tests on my modifications and will present the results here. I have two sets of recommendations to make. The first deals with the construction of the BalloonSats and the second in the construction of their carrier. I'll close this month's column with two cautions about constructing for near space.

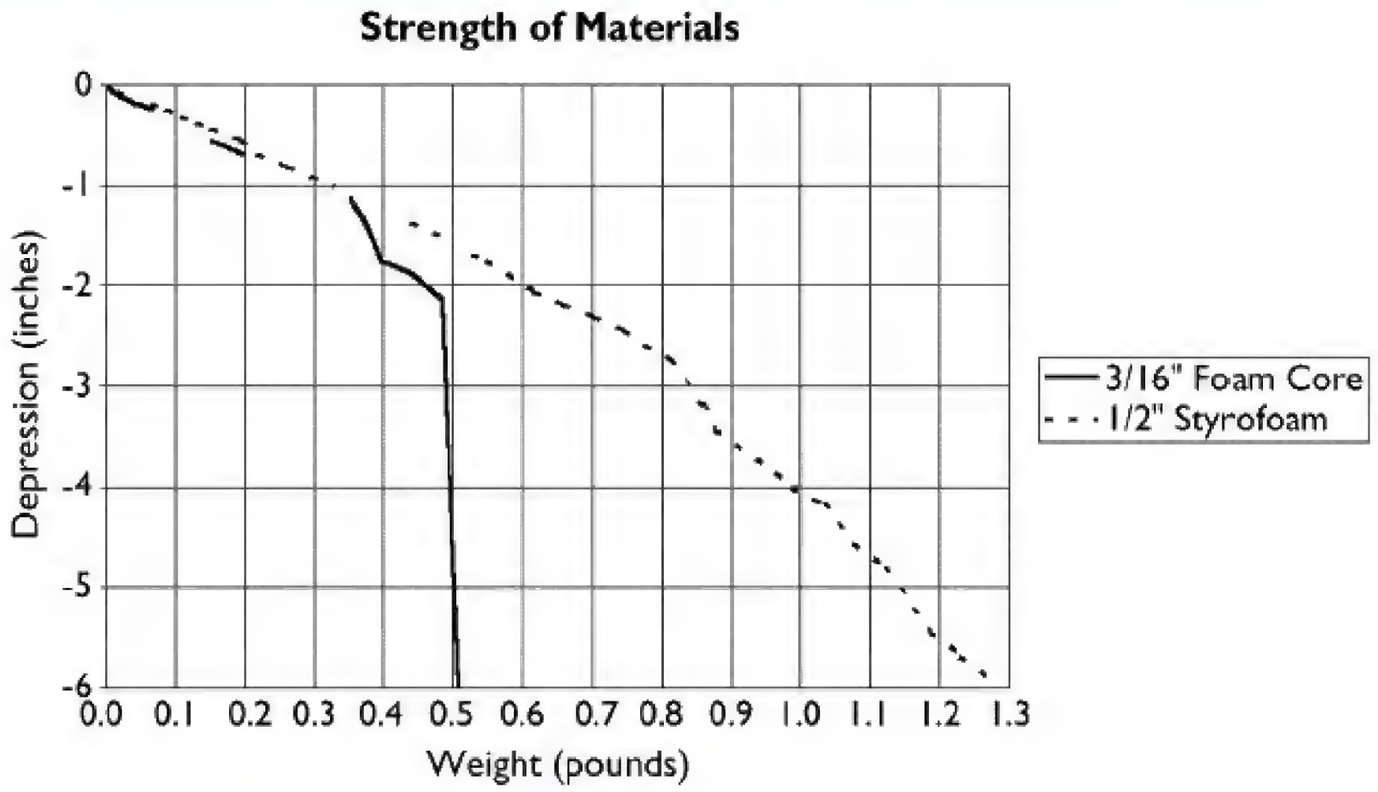


Figure 5. Chart showing the strength of the materials.

My Recommended Modifications to the BalloonSat

I have four recommended changes in the construction of BalloonSats. These changes involve changing the airframe material, changing the type of external insulation, using a new closure method, and changing the tubing material. Feel free to adopt any or all of my modifications.

Using Styrofoam as Airframe Material

Instead of using 3/16-inch thick foamcore, a BalloonSat airframe should be built from 1/2-inch thick Styrofoam. The thicker Styrofoam gives greater surface area for the glue and is lighter in weight than foamcore. Hot glue bonds the airframe pieces together very quickly and is easier to use than either JB Weld or silicone glue (both are recommended adhesives in the BalloonSat book).

The greater the thickness of a material, the stronger it becomes. But foamcore has a bonded paper surface, making it a composite. So I wondered if this might add to its strength. So, I performed the following strength test.

Two beams of identical dimensions (except for thickness) were cut from 3/16- inch thick foamcore and 1/2-inch thick Styrofoam. Each beam was 24 inches long and two inches wide. The first 12 inches of each beam were supported on a table and weighed down with books. The remaining length (12 inches) extended over the edge of the table. At a point one inch from the end of each beam, I added weights (from a Physics lab). The weights were added slowly so there was no sudden impact of weight on the beams. After adding each weight, I measured and recorded the amount of bending (its depression or deflection) at the end of the beam.

You can see from the chart in Figure 5 that both materials began bending at the same rate. However, the thinner foam core broke at a 1/2 pound of weight while the thicker Styrofoam continued bending — but not breaking — at twice the weight.

I thought the foamcore, being thinner, would weigh less per surface area. It turns out, however, that the paper and glue in the foamcore adds significant weight. I cut a five inch by five inch square of both materials and weighed them on a scale with two ounce precision. The foamcore weighed 10 grams while the much thicker Styrofoam weighed only eight grams.

My next test was to glue together two identical five inch cubes, one from 3/16-inch thick foamcore and the other from 1/2-inch thick Styrofoam. I placed both cubes on a flat floor and stacked weights on top of them (spools of welding wire). Again, I added the additional weight as gently as I could during this test.

The thinner 3/16-inch thick foamcore burst under a weight of 213 pounds while the 1/2-inch thick Styrofoam flexed and cracked under 135 pounds and later burst under a weight of 198 pounds. Perhaps the early flexing of the Styrofoam cube was the sign of a bad glue joint. But either way, being able to support over 100 pounds of weight is sufficient for

Figure 6. Crushed cubes.

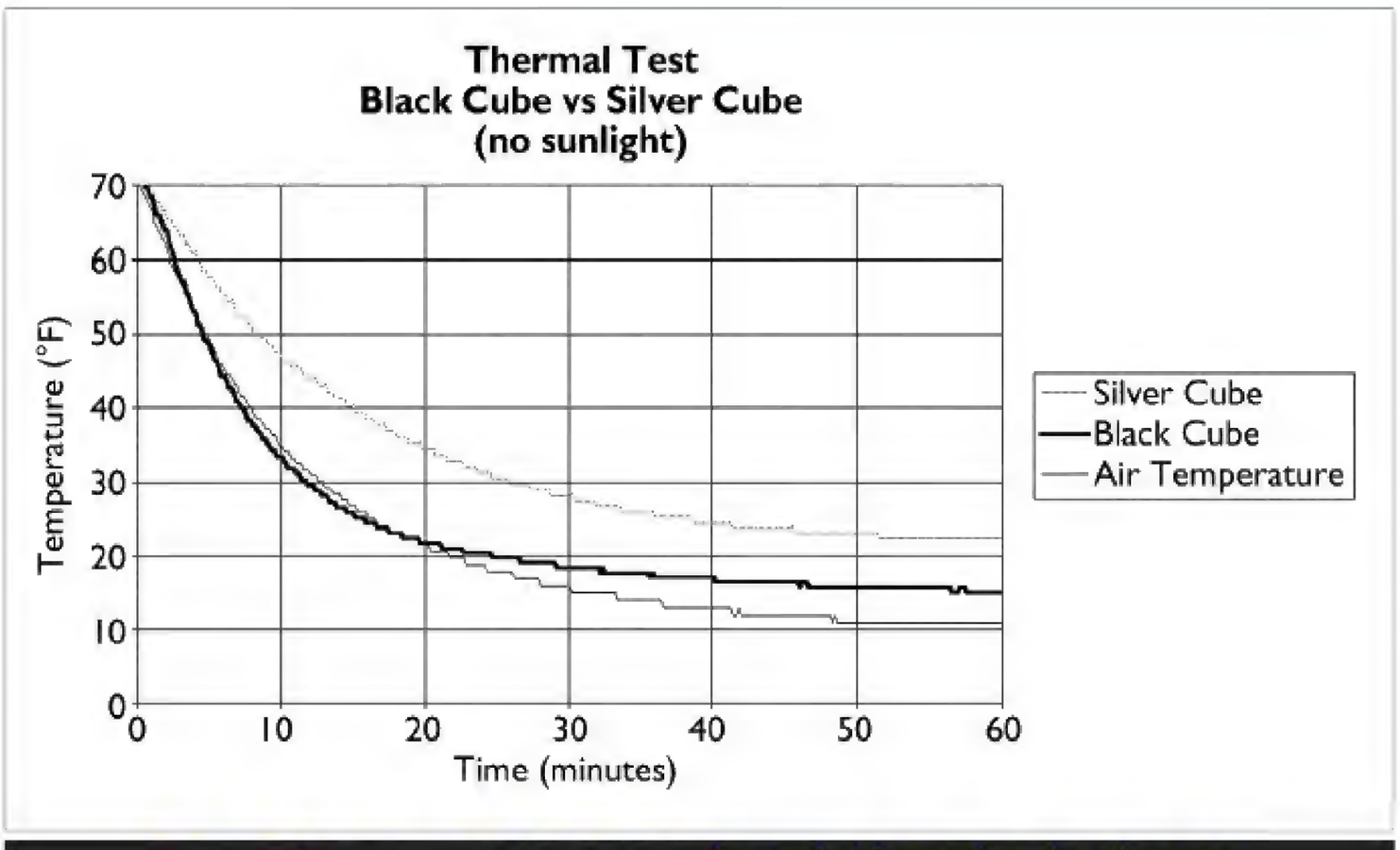


Figure 7. Notice the black colored cube cooled faster than the silver one.

a BalloonSat.

Insulation Changes

Next, I loaded two BalloonSats inside my Thermal Test Chamber (TTC) for testing. The first test compared the internal temperature differences between a BalloonSat wrapped in aluminum tape (the traditional material) and one wrapped in a thin black plastic packaging tape (the kind of tape used to wrap Styrofoam gliders). The second thermal test compared the internal temperatures between BalloonSats wrapped in a traditional aluminum tape and one wrapped in aluminized space blanket.

Initially, I was a bit surprised by the chart in Figure 7 until I recalled something my father had told me. A material painted black absorbs radiation well and reflects very little of it. However, if a black colored body can absorb radiation well, it can also emit it well. I was told this is why the radar antennas on aircraft carriers are painted black and not in white or silver.

Have you wondered why potatoes are wrapped in aluminum foil before being baked in the oven? While the aluminum foil reflects a lot of the infrared radiation emitted by the oven's heating coils, what radiation does get in, stays in, and can't get out. The potato cooks faster as a result.

In the second test, I hoped to see that reducing the amount of metal on the outside of the BalloonSat would reduce the rate at which it cooled. In the chart in Figure 8 you can see that the results are pretty much a wash. There's no significant difference in the rate at which the two cubes cooled.

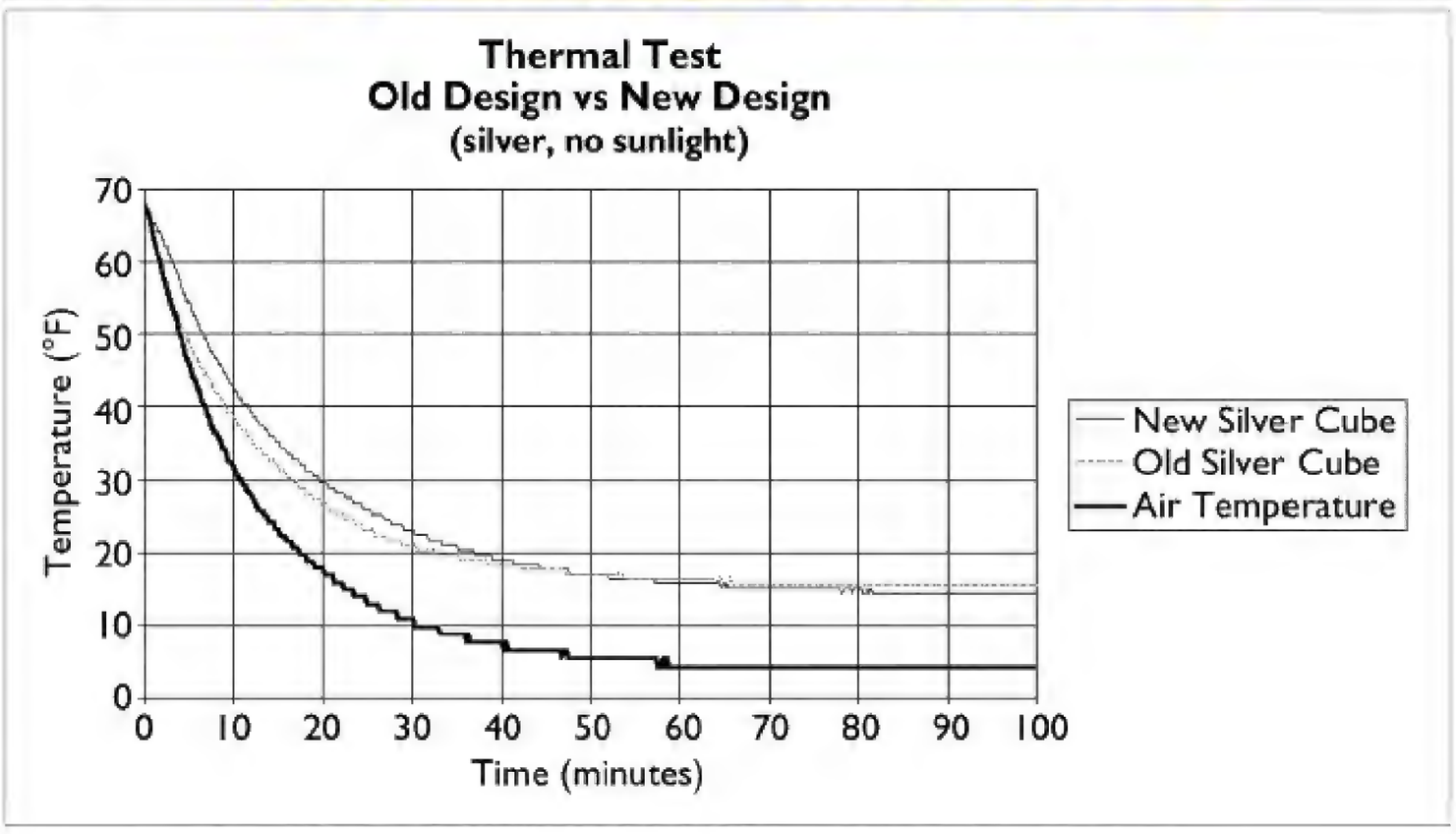
However, the BalloonSat wrapped in space blanket is lighter in weight than the traditional BalloonSat wrapped in aluminum tape. Anything that reduces the weight of the airframe helps meet the weight criteria and permits an increase in instrument weight.

Here's my conclusion on airframe materials and insulation. The five inch cubic foamcore BalloonSat weighs 58 grams initially and 82 grams once it's wrapped in a single layer of aluminum tape. The same size Styrofoam BalloonSat only weighs a total of 58 grams with a space blanket exterior and stays just as warm.

Now if your BalloonSat is not using space blanket, then I recommend using Styrofoam tape in place of the aluminum tape. I'm referring to the tape hobbyists use to wrap the surfaces of their Styrofoam gliders. It comes in multiple colors and is lightweight.

Use a dark colored tape because my past near space experiments have demonstrated that dark colors on the exterior of a near spacecraft keep it warmer. See my article, Keeping Near Spacecraft Warm, in the Fall 2004 issue of *Amateur Television Quarterly*. (Contact the editor, Gene Harlan, at ATVQ@www.hampubs.com to get a copy.)

Figure 8. Chart comparing the old design to the new design.



Closures

The closure on most BalloonSats is either tape or Velcro. My suggestion is to change to rubber bands.

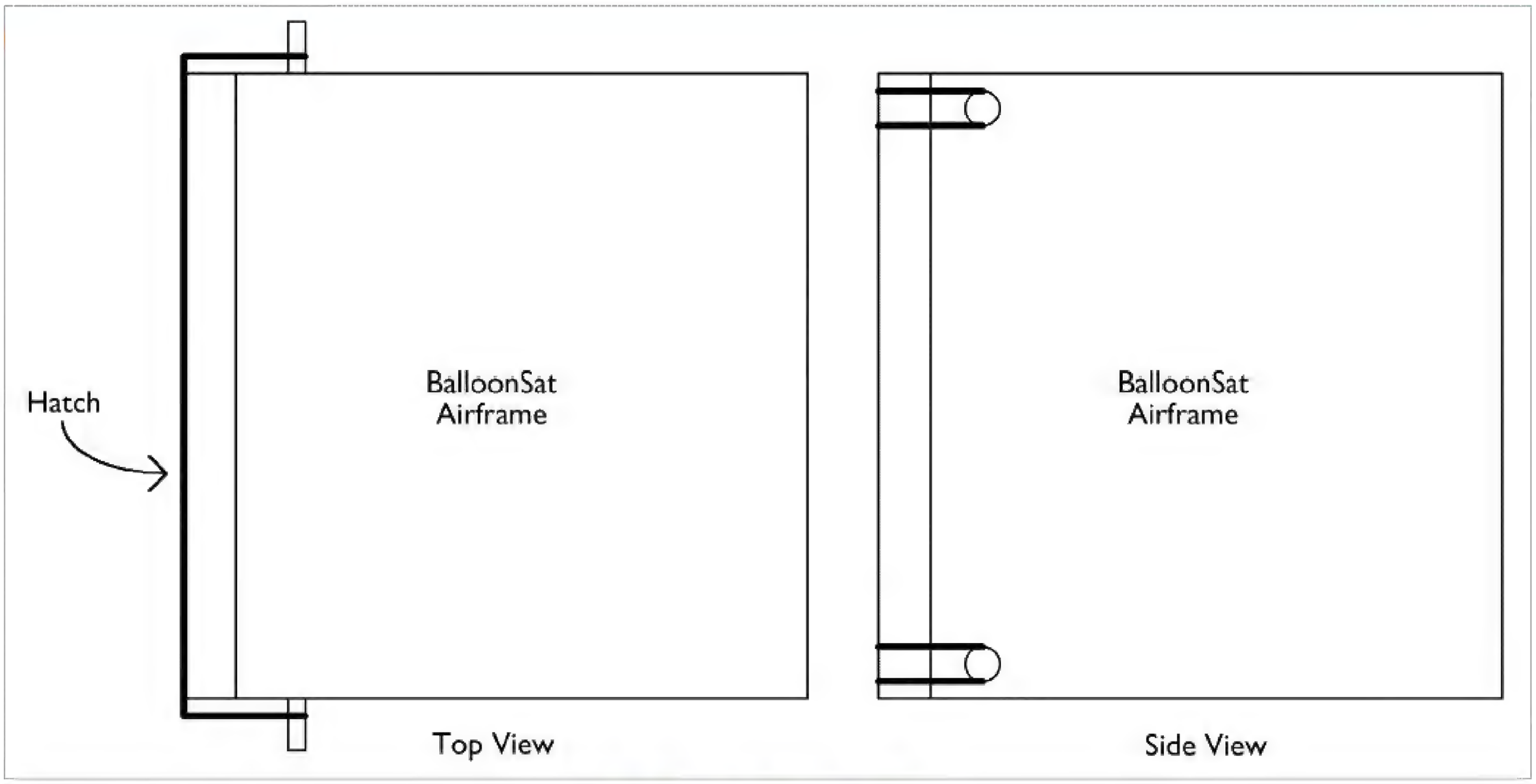


Figure 9. BalloonSat closure.

Rubber bands make quick and cheap closures. My near space experiments have demonstrated the ability of rubber bands to function in the ozone, increased UV, and the cold of near space. So, I currently use rubber bands on all closures of my near spacecraft.

Using rubber band closures requires a simple modification to a BalloonSat, adding and gluing two wooden dowels (3/16-inch diameter dowels work well) into the airframe. Cut the dowels 1-1/2 inches longer than the width of the BalloonSat. I found it best if I carved trenches (for the dowels) into the side, or top and bottom walls of the BalloonSat before gluing the airframe together.

After the airframe is glued together, cover the BalloonSat exterior, insert the dowels, and then lock the dowels into place with a little hot glue. The hot glue also prevents the BalloonSat exterior covering from ripping where it meets the dowels.

BalloonSat Tubing

If the flight line for the BalloonSat goes though a hole in the Styrofoam airframe, the flight line will eventually cut its way through the airframe. To prevent this destruction, BalloonSats have a tube running through their center. I've seen both metal and plastic tubes in BalloonSats. The metal ones add unneeded weight and their edges can chafe the flight line. An alternative is to use a ballpoint pen case, as recommended by the University of Idaho.

The plastic is lighter than metal and plenty strong, however, it has a limitation. Most ballpoint pens have bodies only 4-1/2 inches long (their diameter is fine). What if you want your BalloonSat to be six inches tall?

Many hobby stores sell polystyrene modeling materials. So, purchase a package of plastic tubes, 3/16 inches in diameter from your local hobby store. Each tube in the package is over 12 inches long and since they're made from polystyrene, they're easily cut with an Exacto knife.

If you place a plastic tube down the center of a BalloonSat, the tube will reduce the BalloonSat's useable volume. So, I experimented with placing tubes inside the wall of the airframe and found that it works well. Of course, this means the tubes are off center and will tip the BalloonSat. However, this modification leads to my recommended changes in the BalloonSat carrier, which I describe later in this article.

So, instead of using a single tube

Figure 10. Rubberbands on a BalloonSat. Note that BalloonSats don't have to be square.

Figure 12. Two BalloonSats on a BalloonSat Carrier.

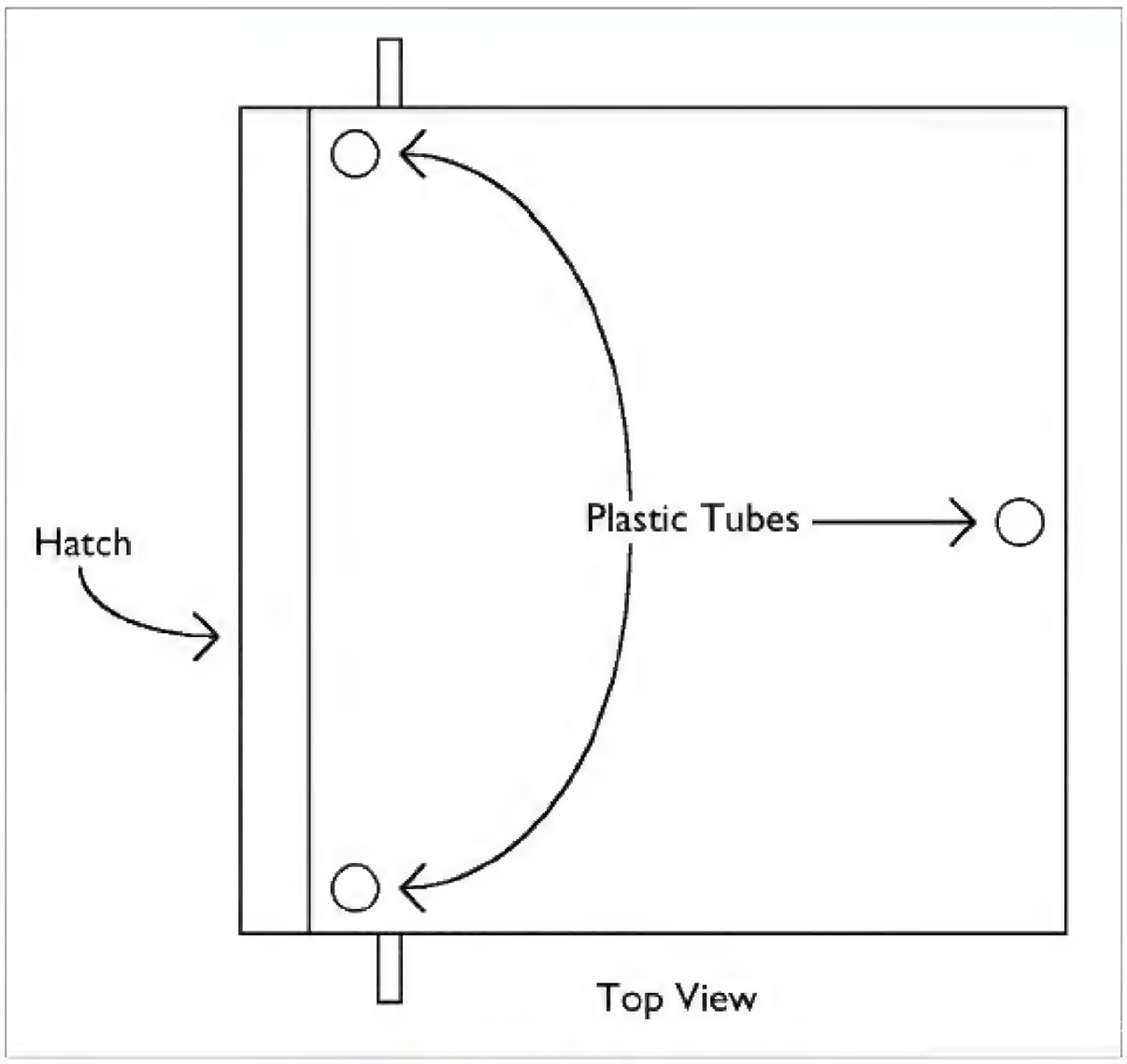


Figure 11. BalloonSat tubes.

through the middle of the BalloonSat, use three tubes and place them in the walls. I recommend first cutting channels for the tubes into the walls of the airframe. You can cut the tube channels by sharpening the end of a tube and spinning it as you push your way through the Styrofoam. Using a brass or aluminum tube in place of the sharpened plastic tube should do a better job, but plastic ones still work well.

Now, cut the tubes to length and glue them into the wall channels with hot glue.

Afterwards, assemble the walls of the airframe with hot glue. I recommend the layout shown in Figure 11 for a cubic BalloonSat. After seeing this layout, you can easily modify it for any other shape BalloonSat.

After assembling the airframe, but before covering it, lightly sand the inside edges of the plastic tubes to remove any rough edges. This reduces any possible chafing on the flight string.

My Recommended Modifications to the Flight String

Notice that my BalloonSat modification requires three flight lines (I call them BalloonSat link lines). Even if one of the lines is cut during a flight (a highly unlikely event when using plastic tubes), there are still two other lines keeping the BalloonSats from falling off. So, I've modified the single flight string into a BalloonSat Carrier for these modified BalloonSats.

You'll need the following materials to make a BalloonSat Carrier:

- Small needle point loop (about six inches in diameter).

• Spectra kite line (I use 50 pound test).

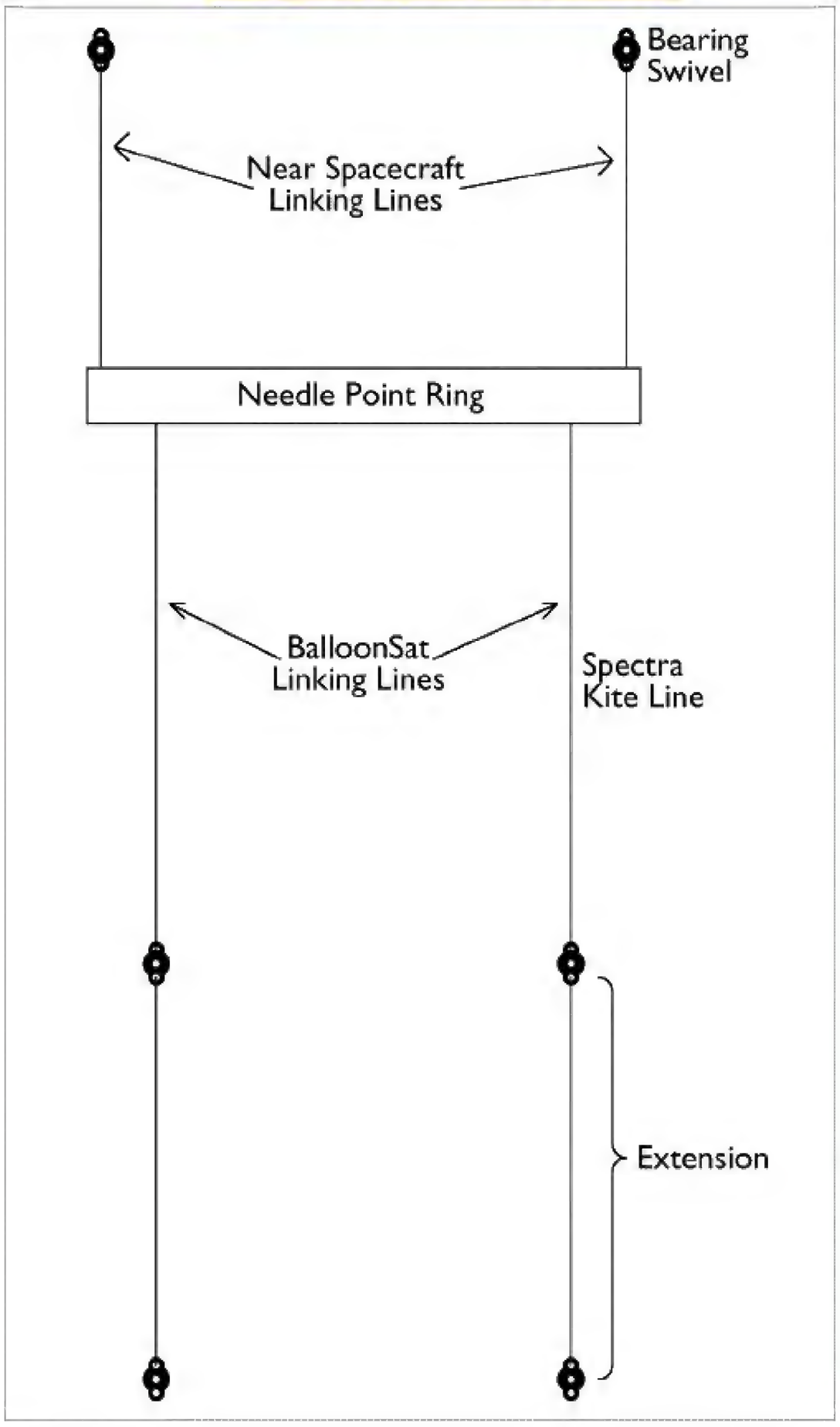
• Bearing swivels small enough to pass through a 3/16-inch tube (I use size 7).

• Split rings (one inch in diameter).

I only use the wooden needle point loops because I don't know if the plastic ones are strong enough. The diagram in Figure 13 gives an idea of how I constructed my BalloonSat Carrier.

Start constructing the BalloonSat carrier by gluing the needle point loop's inner ring into its outer ring with epoxy. Tighten the clamp in the outer ring and let the epoxy set. Afterwards, file the clamp off and fill the open gap with a small piece of wood. Drill three equally spaced holes into the loop (I use a Dremel tool with an 1/8-inch diameter drill bit).

Figure 13. BalloonSat carrier diagram.



Make the BalloonSat Linking Lines by cutting three lengths of Spectra kite line to a length of three feet. Melt the ends of the Spectra to keep them from fraying. Mark the Spectra six inches from the ends with a felt tipped marker.

Now, pass a length of Spectra through each hole in the needle point loop. Center the black mark in the hole and tie the Spectra into place with a knot. To make the knots secure, lay the end of the Spectra line along the rest of the Spectra and then tie an over-hand knot in the doubled-up section of the Spectra.

As long as the marks on the lines are centered in the holes of the needle point loop, the lines will be close to the same length after the knots are tied. Perhaps the diagram in Figure 14 will help explain how I tie a doubled over-hand knot (no doubt Boy Scouts reading this article can tell me the official name of this knot).

Mark six inches from the opened end of the Spectra line and use the same knot to tie a bearing swivel to the bottom end of each line. Do not use a snap swivel, as the snap can pull open during the more traumatic times of the flight (like balloon burst). You now have a wooden ring with three Spectra lines hanging down from it that are terminated in bearing swivels.

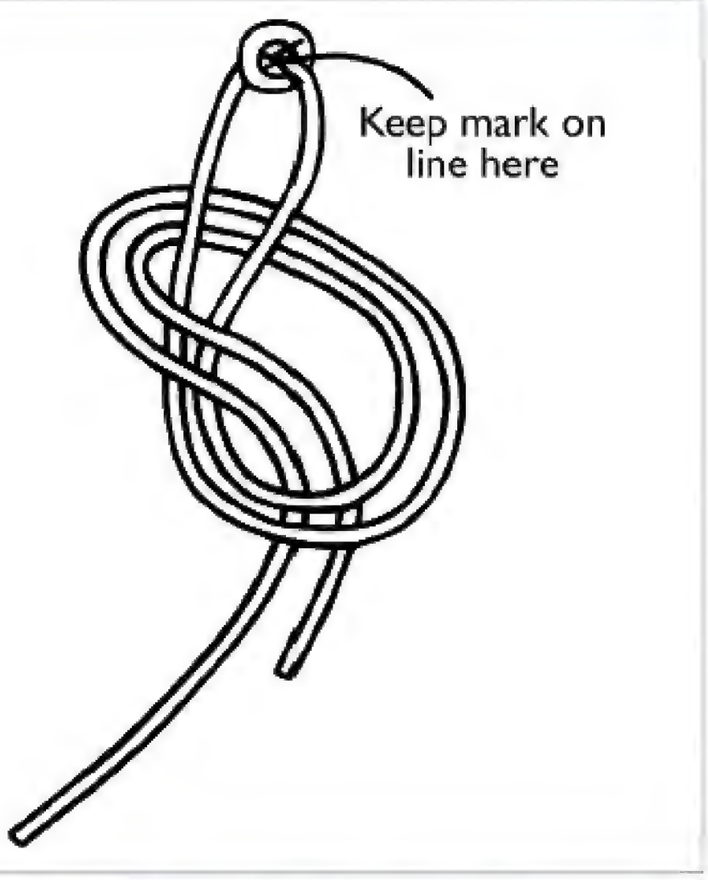
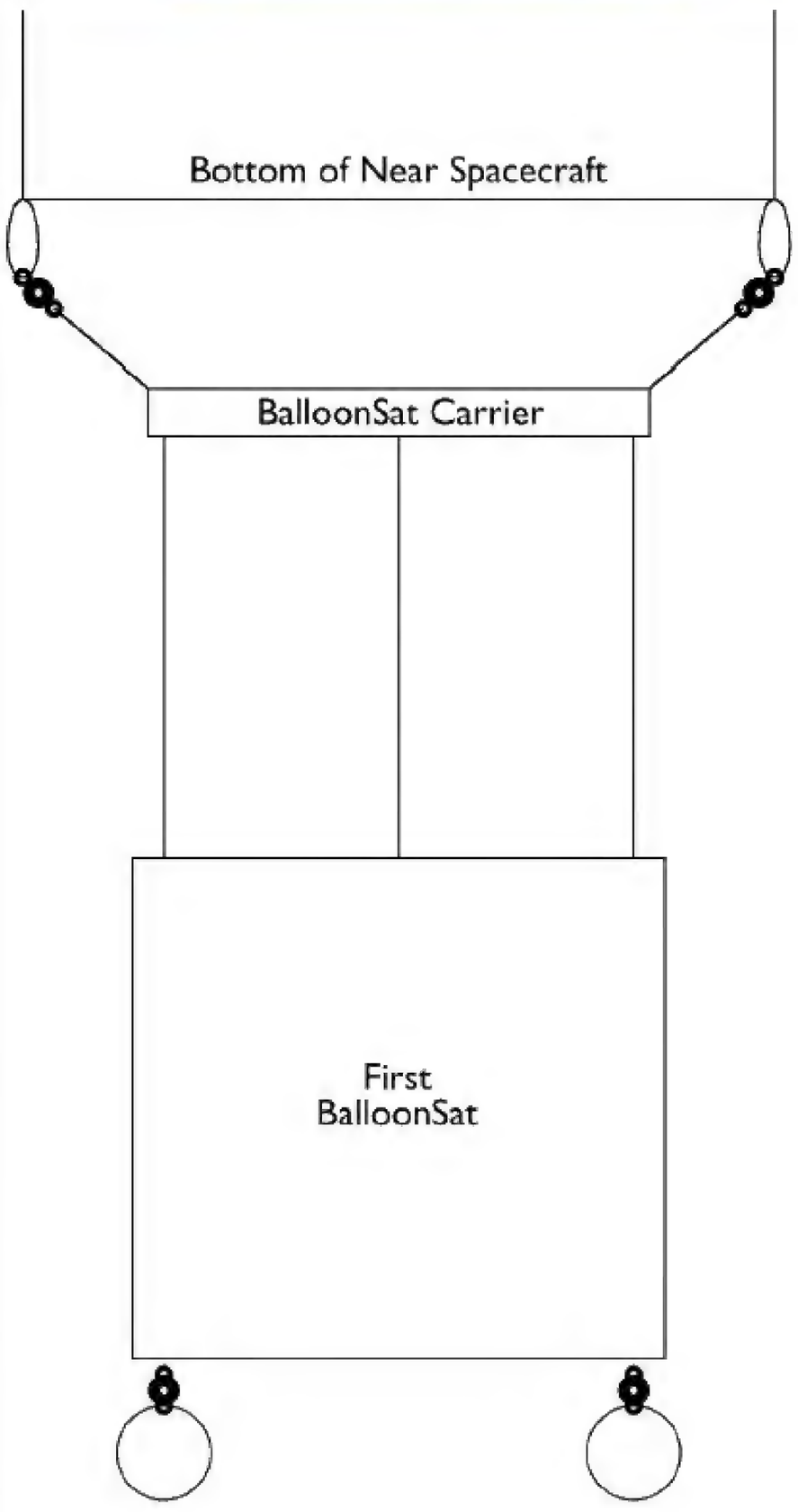


Figure 14. Knot diagram.

Figure 15. Carrier with Sat diagram.



Next, add lines to the wooden needle point loop so the BalloonSat Carrier can be connected to the bottom of the near spacecraft. How you choose to do this depends on the design of your near spacecraft. I design my near spacecraft in nearly identical modules.

At the top and bottom corners of my modules are a loop of Dacron and a one inch diameter split ring. The tops and bottoms of the modules link together with Spectra Link Lines to form the near spacecraft. Even my recovery parachute is attached in this manner. Since I use square modules, I have four linking points on the bottom of each module. So, my BalloonSat Carrier uses four lengths of Spectra to attach to the bottom of the near spacecraft. Your design may differ, so you may need a different number of Spectra lines in your carrier.

If possible, use the same holes for the BalloonSat linking lines to tie the near spacecraft linking lines. Following the same procedure used for the first set of lines, tie three-foot-long Spectra lines into the holes of the needle point loop. Then, tie bearing swivels into the ends of the linking lines.

To attach my BalloonSat carrier, I use split rings to connect the BalloonSat carrier to the bottom of the near spacecraft. After attaching the BalloonSat Carrier to the near spacecraft, slide one BalloonSat onto the lines. Add a split ring to the ends of each bearing swivel to keep the BalloonSat from sliding off. See the diagram in Figure 15 if my directions aren't clear.

To add more BalloonSats, make more linking lines by following the same procedures as described above. Cut three pieces of Spectra three feet long, melt the ends slightly to keep them from fraying, mark six inches from both ends of each line, and center a bearing swivel on the marks and tie the swivels into place. You'll now have three additional link lines with bearing swivels securely tied to their ends.

To add the second BalloonSat, link the new lines to the split ring at the end of the BalloonSat Carrier (after the first BalloonSat has been added to the carrier). Slide the next BalloonSat in place and add a split ring to the end of the three bearing swivels to keep the BalloonSat from sliding off. You can continue this process for as many BalloonSats as you need to fly. However, keep in mind the weight limits imposed by FAR 101 when adding BalloonSats.

I see a couple of benefits in using this design of a BalloonSat Carrier. First, the multiple flight strings will reduce BalloonSat swinging and spinning during the flight. The BalloonSat Carrier forms a more stable platform than a single flight line because as the BalloonSats try to swing or rotate, the other link lines are put under different tension and resist the motion.

As a result, images recorded during a flight should show sharper detail.

The second benefit comes from using bearing swivels. The length of the BalloonSat Carrier can easily be changed from mission to mission. If the next flight carries more BalloonSats, you just add an extension to the current carrier.

Also, since the lines are linked together, it's easy to untie knots that may form in the Spectra during storage. And by disconnecting the link lines, tangling is reduced to begin with. Bearing swivels let the

link lines rotate independently of each other, reducing their tendency to tangle. The Spectra kite line is a tough string with a smooth finish. You'll find it's thin, durable, and resistant to fraying, unlike nylon line.

The final benefit is the fact that the BalloonSat Carrier is reusable. As long as you remove and store the carrier, you won't lose or tangle the strings.

Some Final Cautions

Here are some things I've seen go wrong on BalloonSats or in my own experiments (I would prefer to learn from other people's mistakes rather than from my own, but alas, that's not always been the case).

Windows

Avoid windows over cameras. This is an example of one of my earliest mistakes and I've seen it made elsewhere. Since it's cold in near space, the first response of designers is to close off all openings in the airframe in order to keep the cold air from infiltrating. The result, however, is that you end up creating a cold surface where internal moisture will condense.

The window fogs up early in the mission and eventually that conden-

Cutting Styrofoam

FIGURE A. Unsquare cut.

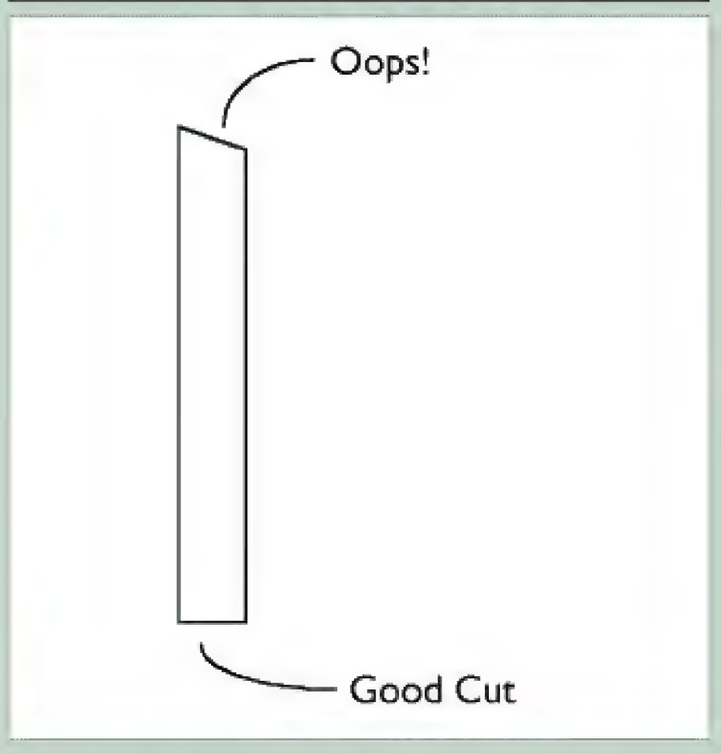


FIGURE B. The angle on this Exacto knife is too steep for the first cut.

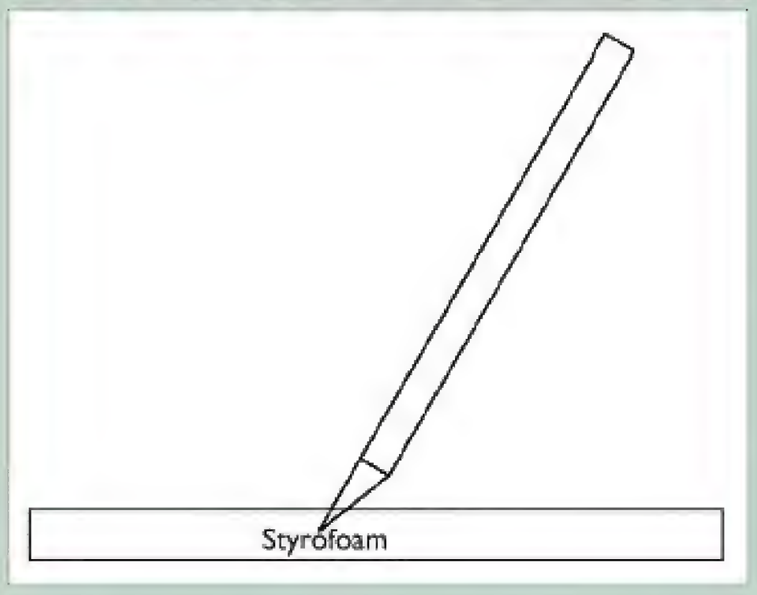
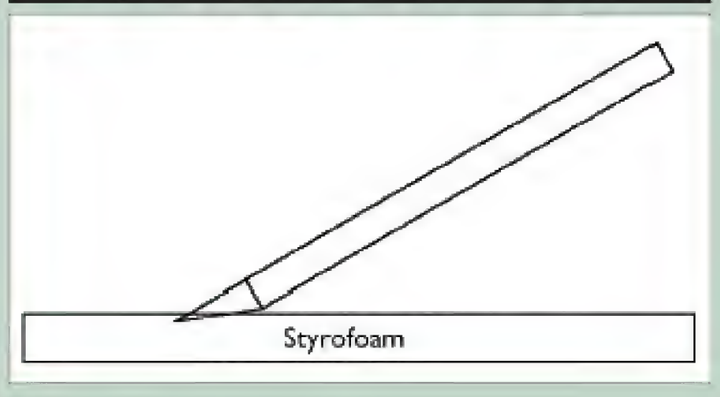


FIGURE C. Holding the blade as horizontal as possible creates the smoothest edge.



One of the difficulties in making an airframe is cleanly cutting the Styrofoam panels. I've found that a table saw makes clean cuts in Styrofoam as does a hot wire (which cuts through Styrofoam like a knife through, well, you know ...). The table saw cuts a naturally straight line, while the scroll saw requires care or a jig. If you're like me, you don't have access to either of these tools and can't justify purchasing them. Our only option then is to cut Styrofoam with an Exacto knife.

Styrofoam is cut straight and cleanly with a metal straight edge and a sharp Exacto knife. I lay out my cutting line lightly in pencil and take care to hold the Exacto knife as close to perpendicular to the Styrofoam sheet as possible. When I'm not careful, I end up with an edge that looks like what's shown in Figure A.

Make your first cut with the Exacto knife leaning back as far as possible. Make several passes through the Styrofoam and don't try cutting through in a single pass. As you cut deeper, stand the blade more upright.

A #11 Exacto blade works well for 3/4-inch thick Styrofoam. For Styrofoam one inch and thicker, use a 2-1/2 inch long blade (this blade requires the larger Exacto handle).

As the blade of an Exacto knife begins to dull, you'll notice that it cuts one direction better than the perpendicular direction. Apparently, there's a "grain" in a Styrofoam sheet. I imagine the grain is created as the Styrofoam is extruded. A dull blade begins breaking chunks out of the Styrofoam, instead of making smooth cuts. Once a chunky edge has been cut, I find that I cannot trim the chunky edge away with a sharp blade. Instead, I have to make an entirely new cut away from the damaged edge.

By using a sharp blade and holding it as close to flat as I can, I end up with smooth cuts in Styrofoam. Since you can go through a lot of blades, purchase your Exacto blades in the black, plastic box of 25 blades. The cost per blade is low, the box protects the unused blades, and the box is a safe place to dispose of the dull (but still sharp) blades.

FIGURE D. The edge of Styrofoam cut with a dull blade. (I used a very dull blade to emphasize the damage done by the blade.)

FIGURE E. The edge of this Styrofoam sheet is much smoother when cut with a new, sharp blade.

sation turns into frost. The camera stays warmer, but it can only photograph near space frost. It's better to make as small of an opening in the airframe as you can get away with. Be sure the camera and its light sensor can see out of the hole.

If the camera has a separate sensor for focusing, then make sure it too can see outside the BalloonSat. Since its always a bright and sunny day in near space, the camera doesn't need a flash. So cover up the flash with black electricians tape so that any flash bouncing off the interior walls of the airframe can't reflect back into the camera lens.

BalloonSat Heaters

Student engineers warm the interior of their BalloonSat by placing chemical hand warmers inside the airframe. Hand warmers, like those by Grabber Mycoal, use oxygen in the air to oxidize iron powder. Hand warmers are effective at warming the BalloonSat before launch. However, as the BalloonSat ascends, the air pressure decreases, and therefore, so does the available oxygen. At some point, the hand warmer should no longer produce significant (any?) heat. It's just excess weight at that point (a good experiment would be to measure their heat output as a function of air pressure).

My recommendation is to warm the interior of the BalloonSat while waiting for launch and to remove the heat packs just before launch. Using a rubber band closure for the BalloonSat makes this fast and easy. Perhaps better than a chemical hand warmer is to use a handheld hair drier. If a source of power is available, warm air can be blown into each BalloonSat while it waits for launch. Be careful that the hair drier temperature isn't so high that it melts the BalloonSat.

In Closing

If you'd like to read more about BalloonSats, you can get a copy of the University of Idaho's BalloonSat Handbook, *Idaho Balloon RISE*, at **www.uidaho.edu/nasa_isgc/RISEmanual.pdf**

If you're flying near spacecraft of your own, please consider carrying BalloonSats. Not every university Space Grant can fly their own near spacecraft and they depend on people like us to help out. Since you're flying with amateur radio, you can't make a profit. However, you can ask to have your costs reimbursed. As far as I'm concerned, the best way to explore near space is with OPHe (Other People's Helium)!

Onwards and upwards,
Your Near Space Guide **NV**

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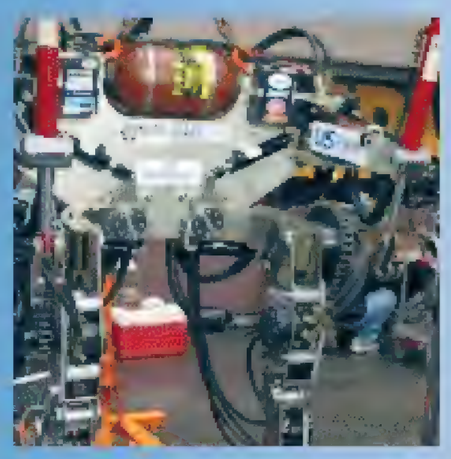

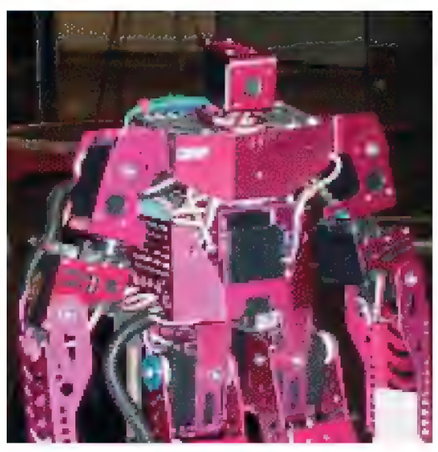

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Tech Forum

QUESTIONS

I recently acquired about 20 four-channel 29 MHz radio-controlled cars and when used as-is, they range as far as 30ft indoors. After slight mods, still good range, but once I install it in my car, the range becomes inches. Why is this? Does the car just block/absorb that much of the signal?

#07051 **Kevin Harris**
St. Louis, MO

I want to build a receiver circuit for a TV remote control. With the number of cheap "Universal" remote controls that are available, I'm hoping to be able to use one of these to control some of my electronics projects, without the need to construct the remote control itself. I'd think other experimenters could utilize such a receiver to add remote control capability to their robotic and other electronics projects. I suppose I could try to salvage this circuit from an old TV or VCR, but since I'm not interested in having a tuner for TV signals, I was hoping for a simpler circuit. I'm also looking for a good book on how to troubleshoot these circuits in various TV and VCR applications.

#07052 **Dwight Johnson**
Booneville, MS

A couple years ago, I bought a Flatfoto 1.3 Megapixel camera. It came with Mac software to download the pictures. I have been puzzled that I can't transfer pictures directly from the SD card, although I can download through the camera.

I recently bought a new three megapixel version for a friend and haven't been able to download pictures to my Mac. The CD that came with it (16-3844) seems to only have Windows drivers. I tried to use the driver from my old Flatfoto 1.3, but it doesn't work. I also tried to access the SD card and that doesn't work either.

RadioShack has been no help. Ideas anyone?

#07053 **Dave**
Millville, NJ

I have a number of IF transformers with no color-coded leads, and the primary and secondary have similar DC resistance. How can you determine the primary from the secondary, specifically the plate (collector) from the grid (base) leads?

#07054 **Richard H. Abeles**
via Internet

I'm using motor controllers with LMD18200 amplifiers in a robotics project, and the amplifiers literally blow up if the motor power is reversed! I'd like to find a simple way to protect from reverse polarity, but without an inline diode or rectifier because of the voltage drop associated with diodes, especially at higher currents when the motor really needs all the voltage it can get. I've been thinking of using a relay powered by the motor power source (usually a battery), but since my motor battery, can be anywhere from 6 to 24 volts there could possibly be too much or too little voltage to run the relay coil.

It would be nice to avoid old-fashioned fuses, as well.

#07055 **Stew**
via Internet

I would like to add FM radio signals to our prison cable system

This is a READER-TO-READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

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ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address if responding by email or we can not send payment.
- Your name, city, and state, will be printed in the magazine, unless you notify us otherwise. If you want your email address printed also, indicate to that effect.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

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To be considered

All questions should relate to one or more of the following:

1) Circuit Design
2) Electronic Theory
3) Problem Solving
4) Other Similar Topics

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- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

Helpful Hints

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address, Phone Number, and Email. Only your name, city, and state will be published with the question, but we may need to contact you.

(94.3 MHz on Channel 60, etc.). I'll probably have to go "off the shelf" to keep it simple for staff to assemble. I'm told that RCA makes an AV accessory box for connecting AV inputs to TVs that only have a coaxial input. These boxes supposedly have an output signal tuneable to most UHF channels. I'll connect an audio cable from a radio tuner to the AV input on this box. But I believe the boxes may not have a cable input. How can I combine the AV box output with the existing cable-ready feed? Can I use a CATV splitter in reverse? Could I use one of those adapters for adding an in-line UHF antenna?

I know that an electrical hobbyist could easily connect a transistor radio to an RF modulator to do what I want, but designing that circuit is beyond my skill level. If someone could send me a circuit diagram, I might be able to convince staff to let me assemble it on a breadboard (no soldering irons in here!). Any help would be appreciated. You may write to me directly at:

CSP E4.12
Box 777
Canon City, CO 81215-0777

#07056 **Sam Graumann**
Canon City, CO

ANSWERS

[#1054 - January 2005]

Need a lens to convert a common PC board camera into a microscope with magnification between 60 and 150X.

I needed something like this also and found it much cheaper to purchase an Intel Play QX3 USB Microscope. It offers magnifications of 10, 60, and 200x. The best place to find one of these today is to look on eBay where they have been selling in the $10.00 to $20.00 area. A recent search showed 28 that sold for less than $20.00 and 17 that sold for less than $10.00!!! Many of them were sold new, still in the sealed box. I have had very good luck with the one I purchased for $10.00.

K3PGP - John
via Internet

[#05051 - May 2005]

I have stereo amps – Fisher, H. H. Scott, and RCA – that use output tubes (6.6-V, 6BQ5, 9199, etc.) that are no longer available. I would like to use transistors instead of tubes for output.

#1 First, large vacuum tubes are not extinct. There is an ad in this magazine (**www.surplussales.com**) that boasts, "over 1,000,000 tubes in stock." Antique Electronic Supply at **www.tubesandmore.com** is a place I can recommend. A simple web search for "vacuum tube" comes up with a couple of million results including an easy dozen commercial vendors. Another route is to search

for guitar amplifiers and their parts.

Second, if you want to redesign the output stage of a tube amp, your best bet is MOSFETs (**www.mouser.com**). They act more like tubes than bipolar transistors, and don't suffer as much loss of current gain at high voltages. In fact, you will need to suppress their current gain with a "cathode" resistor and/or a negative feedback loop in order to reduce their performance to resemble a vacuum tube. I've never seen a vacuum tube that would go from zero to four amps for two or three volts of grid signal, but MOSFETs do. Then, there is the matter of designing DC bias supplies, limiting the drive voltage for the phase that shuts off each MOSFET, and adjusting for minimum distortion.

There is no way to just plunk a drawing in your lap because every tube design is peculiar to the available voltage and the output transformer. On the other hand, tube amps are simpler than you might think. After all, most of them were designed about 50 years ago. My favorite tube book is *Tube Audio Design* by Bruce Rozenblit. He covers the basics in about 60 pages, then does another 60 pages of examples. If you go through that book like it is a school text book, you will have all the concepts and math required to "fake" a vacuum tube.

Third, if you just want to get the signal to an external transistor power amp, you can simply pick a point before the phase splitters, or off the cathodes of the phase splitters, and build a capacitively-coupled output jack for each channel. That's how I use a transistor amp to troubleshoot tube amps. I use the volume control on the transistor amp to keep from blowing my ears out when I drive the preamp stages to their limits, and I can hear noise and distortion easier than I can see them on my oscilloscope. Meanwhile, the power tubes are either unplugged or driving into a dummy resistor. Never leave a tube output unloaded. They are current drivers and if you don't load the output current, they react with inductive voltage spikes that often cause smoke to be released.

Chuck Larson
Largo, FL

#2 My first reaction to this question was something on the order of "why would you want to?" But after thinking a moment, I recalled that there are actually some solid-state devices made to directly replace certain tubes. Mostly these are rectifiers, and replace rather hard-to-find or expensive and unreliable rectifier tubes. But there were some made at various times that were intended to replace amplifier tubes, as well. These boasted higher output and better efficiency over their tube counterparts. Some have even built custom replacements using MOSFET devices.

That said, let's get to practicality. If your goal is to own a working H.H. Scott or Fisher amp, check out **www.tubesandmore.com** which is the website of Antique Electronic Supply in Tempe, AZ (480-820-5411). They won't help you replace your tubes with transistors, but they do stock your 6BQ5 tube, and may be able to help you out with a cross for the others. There's hardly a tube found in old amps they don't have and they usually aren't all that expensive. You might consider replacing your tubes with tubes, and keep the amps as original.

Frankly, the point of owning an older tube device is the tubes. If you replace the tubes in your old amp with solid-state, all you'll have is an old amp. The time and expense of modification might well exceed the cost of tube replacement. On the other hand, if you want a solid-state amp, consider this option: your H. H. Scott and Fisher have collector value, even without a complete working set of tubes! You can sell them (on eBay, for example) and partly or wholly fund a new solid-state amp that will be higher power and more reliable, perhaps more to your liking. A recent eBay auction for a Fisher tube receiver closed at $379.00, not bad

Tech Forum

for a piece of 40-year-old electronics!

The preference of tubes vs. transistors is highly personal, there's no clear "right" choice for everyone, and each has its advantages. Tubes are often cited as being prone to failure. Yet a well-known tube amp designer has stated that a properly designed tube amp can be every bit as reliable as a solid-state device. While solid-state products have controlled the market for years, there have been more tube devices manufactured lately than at any time in the last 25 years. Who'd have guessed that would happen?

Jim Addie
La Grange Park, IL

[#05054 - May 2005]

I need an inexpensive I/O card that has about 12 digital input/outputs and six analog input points. It needs to fit into a standard slot in a PC.

Omega.com sells a board for $479.00 **www.omega.com/ppt/pptsc.asp?ref=CIO-DAS16JR**

Have you considered using a microcontroller such as Atmel's ATMega8, connected to your PC's RS-232 port? This MCU has enough onboard I/O to meet your requirements and the RS232 interface is easy to program. I can help you with this if you are interested.

Daryl Rictor
circuithelp@yahoo.com

[#05055 - May 2005]

I was troubleshooting a Tektronix scope's high voltage circuit and I broke a germanium diode. It looks like it functions as a switch in this application. Why would a germanium diode be used in any circuit other than a crystal radio? Are they sometimes used as fusing devices because of their lower current rating?

Will any germanium diode work?

#1 If you gave the scope model, someone could tell you exactly what the diode does and recommend a replacement. It is quite certain that it was not used as a rectifier in the high voltage circuit. Using a diode as a fuse would not be reliable because the failure mode is almost always as shorted. Using a diode as a switch is a common application. If the broken diode is a small glass type, a 1N34A will no doubt replace it.

Russell Kincaid
Milford, NH

#2 That is probally a Tunnel Diode made from germanium. They can switch in less than a nanosecond but the voltage range is about 0.1 to 0.5 volts and are usually followed by amplification. Your best bet is to find a Tek website and try to get a replacement from a similiar model scope. Or at least the same part number. TDs are no longer made and if so, are very rare.

Ken Roibbins
Reading, MA

[#06054 - June 2005]

There is an Internet provider in Calypso, NC which provides broadband Internet service with microwave radio:

www.nboxwireless.net

We need someone to put something like this in our community, as the phone company will not install DSL lines because there is not enough revenue to pay for new fiber optic cables.

#1 I know Curt WB4WAA personally, and am in the exact same situation. The local phone provider here is Sprint, and the cable company is also Adelphia.

Neither wants to invest the resources to make high speed Internet available here in much of Eastern North Carolina.

In a nutshell, in many cases, the economic feasibility is not there for an individual or many ISPs to see any kind of return on investment.

So, looking for a solution, I approached a local ISP (NCISP) and they agreed to try a cost sharing

wireless alternative. I live about eight miles out of town, and we did a business case study. In the subdivision I live in, there are about 30 homes clustered. I contacted every home owner in the subdivision, but only three showed any interest to the point of committing to high speed for around $30-$50 a month. We were surprised on how few people in a rather affluent area showed no interest whatsoever in high speed, even though many of them (probably at least 50-60%) use dial-up daily. So, we had to base our business model on net revenue of $150.00 a month, with me providing electricity, tower space, and the ISP doing the same gratis.

I have a 60 foot ham tower in the back yard. We both went in half, and purchased a microwave radio back bone made especially for point-to-point ISPs.

We both agreed to try and limit the cost to less than $2,000.00 apiece in capital outlay, with me paying for the link on my end, and the ISP on the other.

This ISP already has a backbone Internet connection, so that cost was underwritten by him. Most other hams will have to pay more than $100.00 a month for just the connection to an Internet backbone.

Unfortunately, we could not make the eight mile hop with antennas in our price range on a 60' tower on this end and a 12 story building roof eight miles away on the other. The path was unobstructed, but with the limited (36") antenna size, we just couldn't get a reliable connection.

To make this work, it would have required a much taller tower on this end with larger antennas. And, with only three persons committing to service, the cost to go any further would have been a net loss for both me and the ISP. We abandoned the project.

I am very familiar with the situation Curt mentions in Calypso, NC. There are two cell phone towers there that are about 300 feet tall.

I assume that this company he speaks of might be making a profit, if they can serve at least a few hundred customers. The last rural company in Calypso, underwritten by US government grants, went belly up about two years ago. Cell phone tower space rents for over $1,000.00 a month on the towers he speaks of. Add to that another $300-$500 a month for bandwidth to the Internet backbone, equipment costs, electricity, maintenance, and depreciation, and you can quickly see that even if every member of the local ham club signed up (~ 35 members), it would not support this business model.

And, of course, most of the local hams in the area already have high speed that want it.

It's just not feasible in most areas without high speed for an individual or small group to put together a system that will come anywhere near breaking even. And, in more densely populated areas, cable and DSL are already installed, negating any possible business model being successful.

I am sure there are exceptions, and perhaps someone with deeper pockets than me, who is willing to pay $100.00 or more a month for high speed could obtain it.

Hope this sheds some light on the situation. All we can do is wait for cable, DSL, or some other technology to come along. It looks to be a decade away for many of us in rural Eastern NC.

E. Kirk Ellis, KI4RK
Pikeville NC

#2 I would suggest something rather simple:

Order satellite Internet service.

www.rapidsatellite.com came up in a quick Google search.

It's really not that expensive on a month-to-month basis.

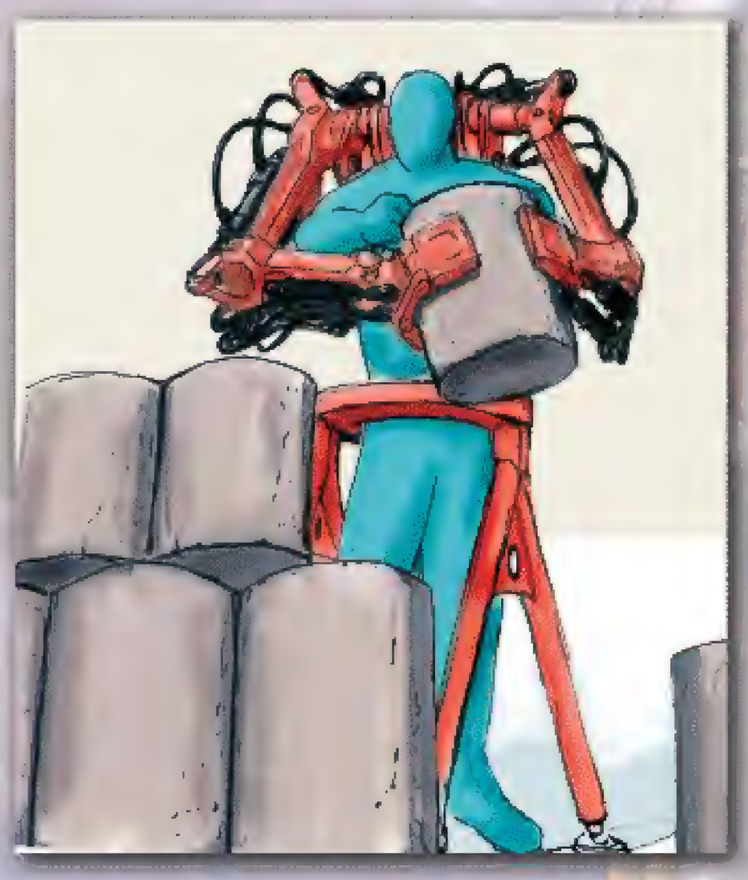
Alex Belenkiy
Staten Island, NY

There's still time to enter!

It's Back ...

TETSUJIN 2005

Although the June 13th registration deadline has passed, there are still a few spots open for serious teams to enter this revolutionary robotic event! Don't let this opportunity pass you by — sign up to participate in SERVO Magazine's powered exoskeleton competition! Choose from three different challenges.



CHALLENGE 1:

Weightlifting. **Ascend stairs in your suit to the lifting platform and lift a load of from 100 to 1,000 lbs* from a squatting position to a height of at least 24 inches*, return the load to the ground in a controlled manner, and descend the stairs. Stair-climbing may be unpowered. The winner is the competitor who lifts the most weight.**

CHALLENGE 2:

Dexterity. **Stack nine concrete cylinders weighing about 70 pounds each in a 4-3-2 vertical arrangement, but don't knock them over as the pyramid grows! The winner is the competitor who arranges the cylinders in the shortest time.**

CHALLENGE 3:

Walking Race. **Walk the 100 foot* long U-shaped challenge course, stepping over a small obstacle at the half-way point. The shortest time wins, with a time bonus being granted based on any auxillary load carried. Walking must be powered.**

The current rule set is available online at

www.servomagazine.com/tetsujin2005

and questions can be directed to

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**Specifics of the competition are in a tentative state and may be subject to change.*

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All of our Panel Meters have **Special Quantity Prices Available.** Visit our web site: **www.circuitspecialists.com** for details

Details & Specs at Web Site
> **Panel Meters** > **Digital Panel Meters**

LED Panel Meters:


9V Independent Ground (PM-129A).....$12.49


5V Common Ground (PM-129B).....$12.95


9V Independent Ground (PM-1029A).....$14.95


5V Common Ground (PM-1029B).....$15.95


9V Independent Ground (CX102A).....$11.49


5V Common Ground (CX102B).....$14.95

LCD Panel Meters:


Jumbo 9V Independent Ground (PM-1028A).....$12.95


Jumbo 5V Common Ground (PM-1028B).....$13.95


9V Independent Ground (PM-128A).....$10.25


Add On Board for CX101 & CX102 Series (CX-ADD ON BOARD).....$4.50

LCD Panel Meters:


Selectable 5V/9V, AC/DC version (PM-128E).....$12.25


9V Independent Ground (PM-138).....$10.90


9V Independent Ground (PM-188BL).....$12.50


9V Independent Ground (PM-228).....$12.50


4-1/2 Digit 9V Independent Ground (PM-328)....$19.88


9V Independent Ground (PM-438).....$10.95


Miniature 9V Independent Ground (CX101A)....$13.50


Miniature 5V Common Ground (CX101B).....$13.50


Miniature 5V Common Ground (CX101BG).....$13.95

www.CircuitSpecialists.com

Circuit Specialists Soldering Station w/Ceramic Element & Seperate Solder Stand

$34.95!

- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
- 3-prong grounded power cord/static safe tip
- Seperate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

Item# **CSI-STATION1** *Rapid Heat Up!*

***Also* Available w/Digital Display & MicroProcessor Controller**

Item# **CSI-STATION2A**

$49.95

Details at Web Site

SMD Hot Tweezer Adaptor Fits **CSI Stations 1 & 2**, and also **CSI906**

$29.00

Item# **CSITWZ-STATION**

> **Soldering Equipment & Supplies** > **Soldering Stations**

In Business
Circuit Specialists Inc.
Since 1971

Bullet Style B/W Camera

- Weather Proof
- Signal System: EIA
- Image Sensor: 1/3" **SHARP CCD**
- Effective Pixels: 510 x 492
- Horizontal Resolution: 420TV lines
- Min. Illumination: 1Lux/F1.2

Item# **VC-305**

1-4:**$49.00** 5+:**$46.00**

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

Item# **CSI825A++**

MicroProcessor Controlled !

Includes 4 Nozzles!

FANTASTIC VALUE!!

Only **$199.00!**

SMD RE-WORK SYSTEM w/Vacuum Pick-up tool

Details at Web Site

> **Soldering Equipment & Supplies** > **Rework Stations**

PC Based Scope Card

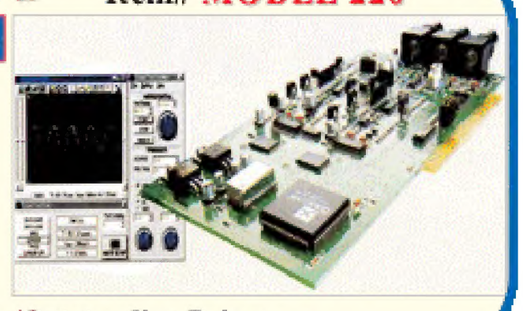
Item# **MODEL 220**

See Details on Web Site

- 32K samples/Channel memory
- Includes software and a CD ROM
- 20Ms/S Sampling rate/Channel
- Scroll mode has sweep times to 1Hr/Sec
- Voltage and Time Cursors
- Voltage Range: 50mV to 5V, 7 Steps
- Time Range: 50ns/div to 0.5s/div,1-2-5 22steps

A $189.00 Value!

Only **$109.00!**



Technical Details at Web Site > **Test Equipment** > **Oscilloscopes/Outstanding Prices**

Triple Output Bench Power Supply

with Large LCD Displays

CSI3003X3/$179.00
(qty **5+/$169.00**)

Output: 0-30VDC x 2 @ 3 AMPS & 1ea. fixed output @ 5VDC@3A
Source Effect: $5x10^{-4}$=2mV
Load Effect: $5x10^{-4}$=2mV
Ripple Coefficient:: <250uV
Stepped Current: 30mA +/- 1mA
Input Voltage: 110VAC

Details at Web Site

> **Test Equipment** > **Power Supplies**

Protek 100MHz Realtime Scope

Super Blowout Price!

2 Ch Dual Trace
6" Internal Grid
ALTMAG
ALTTRIG
TV Sync
5 Vertical Modes

Item# **6510**

Brand New
Not Refurbished!
Includes 2 scope probes

A $975.00 Value!

100MHz only *$499.00*

While Supplies Last!

Details at Web Site > **Test Equipment** > **Oscilloscopes/Outstanding Prices**

Dual Output DC Bench Power Supplies

As Low As **$93.00!**

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

- Source Effect: $5x10^{-4}$=2mV
- Load Effect: $5x10^{-4}$=2mV
- Ripple Coefficient:: <250uV
- Stepped Current: 30mA +/- 1mA

HOT ITEM!

*Both Models have a **1A/5VDC Fixed Output** on the rear panel*

CSI3003X-5: 0-30v/0-3amp/1-4..**$97.00**/5+..**$93.00**

CSI5003X-5: 0-50v/0-3amp/1-4..**$107.00**/5+..**$103.00**

Details at Web Site > **Test Equipment** > **Power Supplies**

A Complete Electronics Lab

You supply the PC to complete a powerful test system which includes a two channel Digital Storage Oscilloscope, a 16 channel Logic Analyzer, an Arbitray Waveform Generator, two Programmable Power Supplies and two Programmable Clock Generators.

Details at Web Site Item# **ELAB-080**

> **Test Equipment** > **Oscilloscopes/Outstanding Prices**

$495.00

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800-528-1417 / 480-464-2485 / FAX: 480-464-5824

Circle #35 on the Reader Service Card.

3M™ DataCom Cable Tester

UNBEATABLE PRICE

Limited Time Offer

This unit allows for mapping, testing and troubleshooting of various lines, including installed data communications, phone wiring and coaxial cable runs.Performs multiple test on the following cable types, up to 1000 feet in length: Unshielded telephone cables with RJ-11 and RJ-45 connectors; Ethernet 10 (100) Base-T; Token Ring; EIA/TIA-568 A/B; AT&T 258a; USOC; 50 or 75 ohm Coax with F or BNC connectors.

Item# DT-2000

Originally Sold for $200.00!

Includes: Holster, Case, 7 Remotes & Telecom Alligator Clips

Details at Web Site

> Test Equipment > Specialty Test Equipment

2.9GHz RF Field Strength Analyzer

Fantastic Low Price: $1899.00!

The **3290** is a high quality hand-held RF Field Strength Analyzer with wide band reception ranging from 100kHz to 2900MHz.The 3290 is a compact & lightweight portable analyzer & is a must for RF Technicians. Ideal for testing, installing & maintenance of Mobile Telephone Comm systems, Cellular Phones,Cordless phones, paging systems, cable &Satellite TV as well as antenna installations.May also be used to locate hidden cameras using RF transmissions.

Item# 3290

- •WFM/NFM/AM/SSB modulated signals may be measured.
- •Signal Levels up to 160Channels can be displayed simulaneously on the LCD
- •PLL tuning system for precise frequency measurement and tuning
- •Built-in Frequency Counter
- •LED Backlight LCD (192x192 dots)
- •All fuctions are menu selected.
- •RS232C with software for PC & printer interface
- •Built-in speaker

(Includes Antenna)

Details at Web Site > Test Equipment > RF Test Equipment

B&W Pinhole Bullet Camera w/ 1/3" CCD

- •Weather Resistant Housing
- •Signal System: EIA
- •Image Sensor: 1/3" CCD Bullet Hole
- •Effective Pixels: 510 x 492
- •Horizontal Resolution: 380TV lines
- •Min. Illumination: 1Lux/F1.2

Item# VC-305CP

1-4:$49.00

5+:$46.00

Details at Web Site

> Miniature Cameras (Board, Bullet, Mini's, B/W, Color)

$149.00! Very Large Infrared Lamp

Item# VC-IR150

Designed to be mounted in an ideal location so that it will give lighting support to a single or array of low-lux cameras. Generate a large amount of IR light in a vast area and be confident that all your supporting cameras will have sufficient light to provide you with a precise image as the visible light disappears. With it's robust aluminum housing and light sensor it will last for years to come and turn on and off automatically as needed. Power Requirements; Universal AC90V-240V 50/60Hz.

NEW!

Details at Web Site > Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

4 Channel Digital Video Recorder

- •Signal System: NTSC
- •Operation System: Embedded RTOS
- •Video Input: BNC x 4
- •Video Output: BNC x 1 / VCR OUT
- •Resolution: NTSC 720x480/ NTSC 640x240
- •**HDD Capacity:** Max. 120G x 2 or 250GX1
- •Backup: VCR
- •Alarm In/Out: 4 in NO/NC, 1 Out No

Item #'s VR-214 & VR-214-250G

NEW!

Only $289.00 & $429.00

Details at Web Site > Miniature Cameras (Board, Bullet, Mini's, B/W, Color) & Security

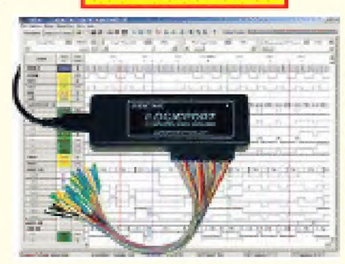
LogicPort Logic Analyzer

$369.00!

The LogicPort provides 34 sampled channels including two state-mode clock inputs. It connects to your PC's USB port for ultimate convenience and performance.

- •34 Channels
- •500MHz Timing mode sample rate
- •200MHz State mode sample rate
- •Real-time Sample Compression
- •Multi-level trigger
- •+6V to -6V Adjustable Threshold

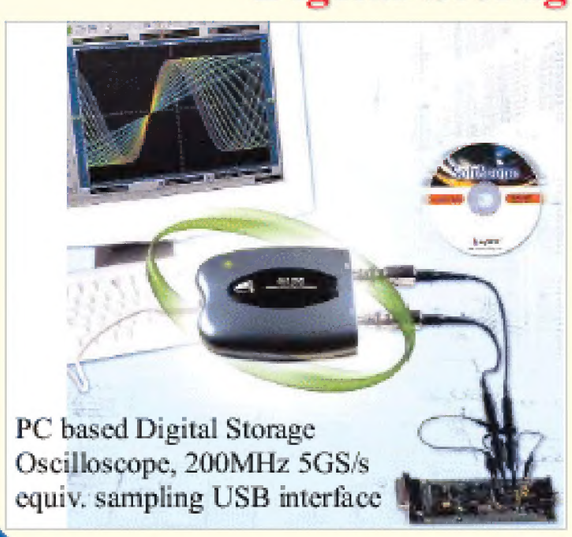
NEW!



Item# LOGICPORT

Details at Web Site > Test Equipment > Logic Analyzers

Digital Storage Oscilloscope Module



PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC basedscope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software Download at Web Site

> Test Equipment > Oscilloscopes/Outstanding Prices

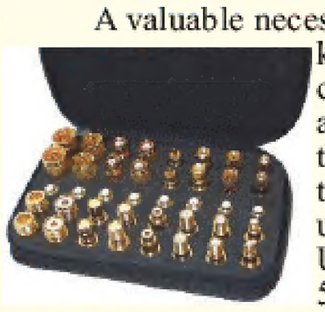
Item# 200DSO Only $899.00

40-Piece Gold Coax Adapter Kit

Item# AY-1000

Only $119.00!

A valuable necessity in connecting any kind of combination of coax termination style to another that you may encounter, be it in the field, lab, or service area. At any time you can custom make an adapter utilizing Male and Female N, BNC, UHF, TNC, RCA, SMA, Mini UHF-50ohm or F-75ohm connectors.



NEW!

Details at Web Site

> Test Equipment > Test Leads & Cable Assemblies

SONY Super HAD CCD Color Weatherproof IR Cameras

480 TV Lines Resolution

- •Day & Night Auto Switch
- •Signal System: NTSC
- •Image Sensor: 1/3" **SONY Super HAD CCD**
- •Horizontal Resolution: 480TV lines
- •Min. Illumination: 0Lux

Item# VC-827D 1-4:$149.00 5+:$139.00

SONY Super HAD CCD B/W Weatherproof IR Camera

- •Day & Night Auto Switch
- •Signal System: EIA
- •Image Sensor: 1/3" **SONY Super HAD CCD**
- •Horizontal Resolution: 420TV lines
- •Min. Illumination: 0Lux

Item# VC-317D 1-4:$69.00 5+:$65.00

SONY Super HAD CCD™ equipped camera's feature dramatically improved light sensitivity

SONY Super HAD CCD Color Camera

- •Weather Proof
- •Signal System: NTSC
- •Image Sensor: 1/4" SONY Super HAD CCD
- •Horizontal Resolution: 420TV lines
- •Min. Illumination: 1Lux/F1.2

Item# VC-805 1-4:$69.00 5+:$65.00

Details at Web Site

> Miniature Cameras(Board,Bullet,Mini's, B/W, Color)

SONY Super HAD CCD Color Weatherproof IR Camera

- •Day & Night Auto Switch
- •Signal System: NTSC
- •Image Sensor: 1/4" **SONY Super HAD CCD**
- •Horizontal Resolution: 420TV lines
- •Min. Illumination: 0Lux

Item# VC-819D

1-4:$89.00 5+:$79.00

SONY Super HAD CCD Mini B/W Board Camera

- •Signal System: EIA
- •Image Sensor: 1/3" **SONY Super HAD CCD**
- •Horizontal Resolution: 420TV Lines
- •Min. Illumination: .05Lux/F1.2

Item# VC-103 1-4:$33.00 5+:$29.00

Visit our website for a complete listing of our offers. We have over 8,000 electronic items on line @ www.CircuitSpecialists.com. PC based data acquisition, industrial computers, loads of test equipment, optics, I.C's, transistors, diodes, resistors, potentiometers, motion control products, capacitors,miniature observation cameras, panel meters, chemicals for electronics, do it yourself printed circuit supplies for PCB fabrication, educational D.I.Y. kits, cooling fans, heat shrink, cable ties & other wire handleing items, hand tools for electronics, breadboards, trainers, programmers & much much more! ***Some Deals you won't believe!***

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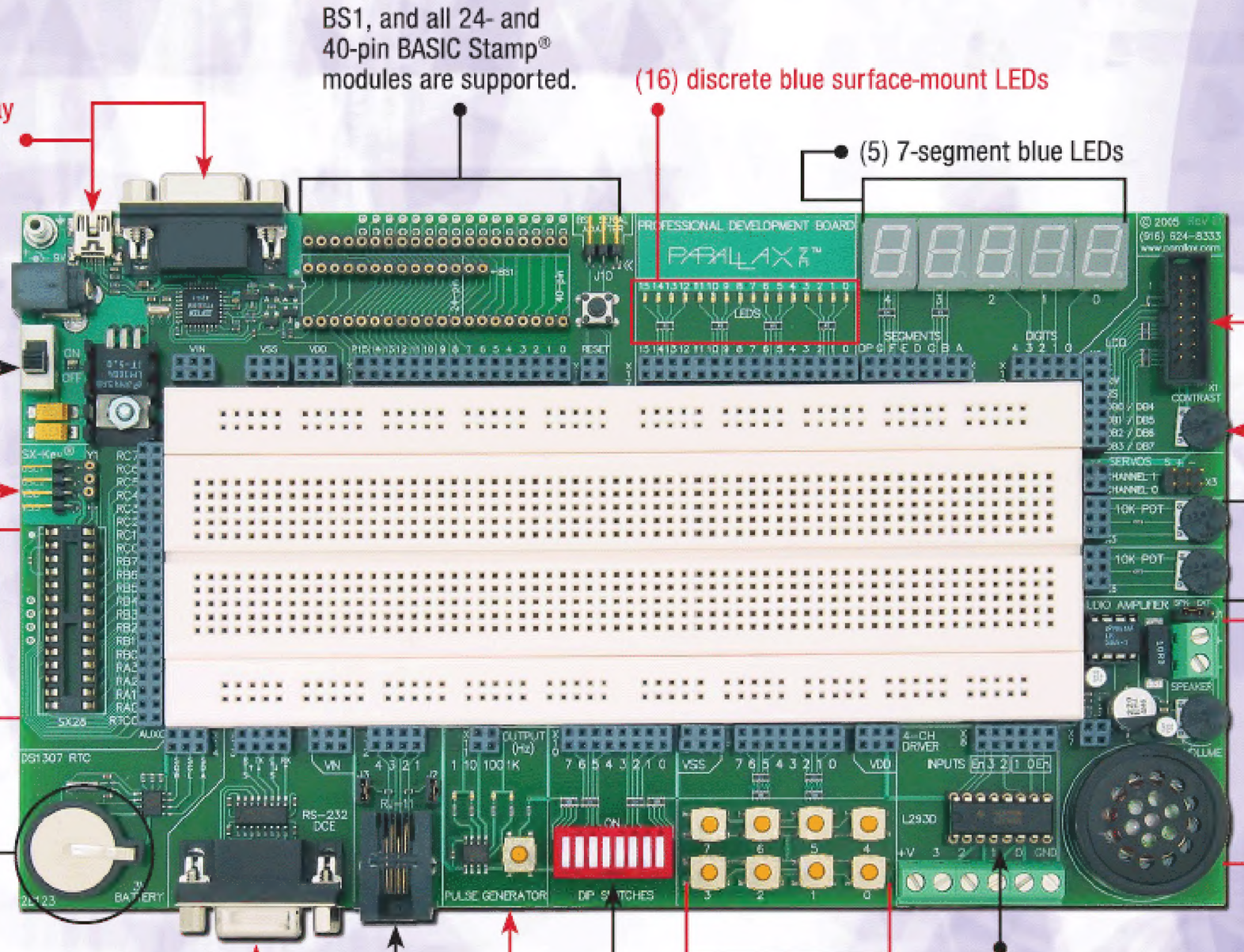
Circle #35 on the Reader Service Card.

Parallax Professional Development Board

Program all BASIC Stamp® microcontrollers and the SX28AC/DP microcontroller with this feature-loaded development board. Popular I/O devices are built-in and a large breadboard provides plenty of prototype space.



$149
stock #28138

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Order online or call our Sales Department toll-free at 888-512-1024 (Monday-Friday, 7am-5pm, PT).

Circle #154 on the Reader Service Card.